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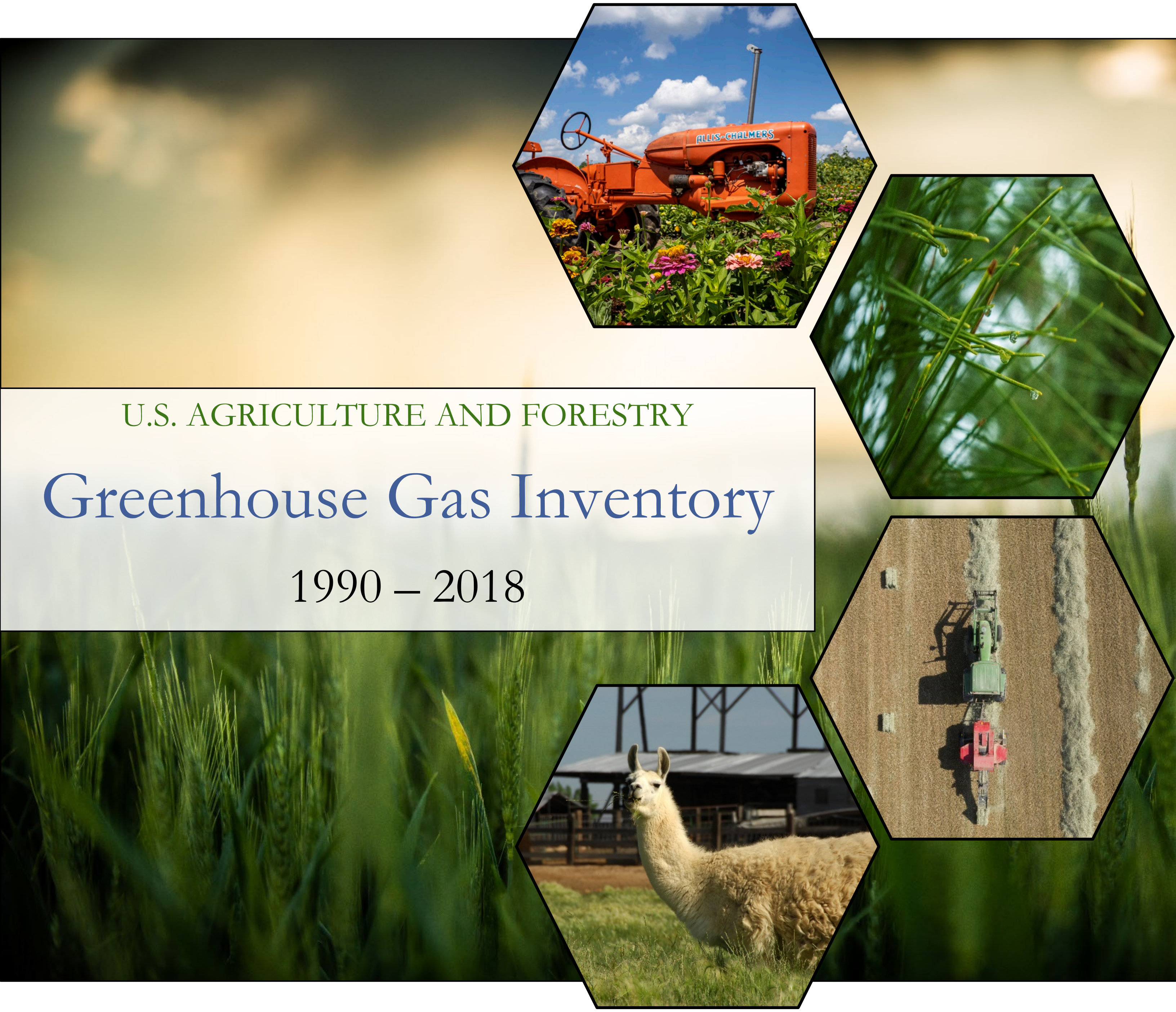
U.S. DEPARTMENT OF AGRICULTURE



U.S. AGRICULTURE AND FORESTRY

Greenhouse Gas Inventory

1990 – 2018

TECHNICAL BULLETIN NUMBER 1957. JANUARY 2022.

Office of the Chief Economist | Office of Energy and Environmental Policy

U.S. AGRICULTURE AND FORESTRY

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U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990–2018.

United States Department of Agriculture, Office of the Chief Economist, Office of Energy and Environmental Policy. Technical Bulletin No. 1957. 181 pp. January 2022.

Data from this report can be downloaded from: https://data.nal.usda.gov/dataset/data-us-agriculture-and-forestry-greenhouse-gas-inventory-1990-2018

Abstract

The *U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990–2018* was developed as part of a periodic series that presents greenhouse gas emissions and sinks from the agriculture and forest sectors. It serves as an update to previous USDA greenhouse gas inventories and revises estimates for previous years based on improved methodologies. This inventory provides a comprehensive assessment of the contribution of U.S. agriculture (i.e., livestock and crop production) and forestry to U.S. greenhouse gas (GHG) emissions. The document was prepared to support and complement information provided in the official *Inventory of U.S. GHG Emissions and Sinks* (U.S. GHG Inventory), which is prepared annually by the U.S. Environmental Protection Agency. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) concentrations in the atmosphere have increased by approximately 46 percent, 165 percent, and 23 percent respectively since about 1750. In 2018, U.S. GHG emissions totaled approximately 6,677 million metric tons of carbon dioxide equivalents (MMT CO_2 eq.), rising 3.7 percent from 1990 estimates. Carbon sequestration in the land use, land-use change, and forestry (LULUCF) sector—which includes managed forests, urban trees, and harvested wood products—reduced emissions to a net 5,903 MMT CO_2 eq. in the United States in 2018. Agriculture, defined as CH_4, N_2O, and CO_2 emissions from cropped and grazed soils as well as on-farm energy use, accounted for approximately 10 percent of total U.S. emissions (677 MMT CO_2 eq.). The primary GHG sources from agriculture are N_2O emissions from cropped and grazed soils (338 MMT CO_2 eq.), CH_4 emissions from livestock enteric fermentation (178 MMT CO_2 eq.), CH_4 and N_2O emissions from managed livestock manure (81 MMT CO_2 eq.), and rice cultivation (13 MMT CO_2 eq.). CO_2 emissions from on-farm energy use contributed 79 MMT CO_2 eq. in 2018. Managed forests, which sequestered 774 MMT CO_2 eq., are the largest managed carbon sink in the United States. In aggregate, the U.S. agriculture and forestry sector provided a net sink of 227 MMT CO_2 eq. in 2018 (including GHG sources from crop and livestock production, grasslands, on-farm energy use, and GHG sinks for cropped and grazed soils, forests, harvested wood products, and urban trees). This report serves to estimate U.S. GHG emissions for the agricultural sector and to quantify uncertainty in emission estimates.

Keywords: climate change, greenhouse gas, land use, land-use change, carbon stocks, carbon sequestration, enteric fermentation, livestock manure, nitrous oxide, methane, rice cultivation, energy consumption.

January 19, 2022

Dear Reader:

I am pleased to present *The U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990–2018*. This report updates USDA Technical Bulletin 1943 (2016), which accounted for greenhouse gas emissions and sinks for the agricultural and forestry sectors through 2013.

This report is consistent with the U.S. Environmental Protection Agency's (EPA) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2018* (April 2020). However, EPA's national scale reporting here has been disaggregated by region or State when possible. Some categories are not directly comparable due to different greenhouse gas source grouping. This format is designed to serve the needs of land managers, planners, and others with an interest in greenhouse gas dynamics and their relationships to land use and land-use change.

Data compilation and analysis, as well as coordination of this *Inventory,* could not have been accomplished without the contributions of Wes Hanson of USDA's Office of the Chief Economist (OCE), Stephen Del Grosso and others within USDA's Agricultural Research Service (ARS), and Laura Gallagher who served on detail to OCE from USDA's Agricultural Marketing Service (AMS). I would also like to thank Grant Domke of the USDA Forest Service (FS); Cortney Itle of Eastern Research Group (ERG); Stephen Ogle at the Natural Resources Ecology Laboratory of Colorado State University; Irene Margaret Xiarchos and Jan Lewandrowski of OCE; Peter Vadas of ARS; Ron Sands of USDA's Economic Research Service (ERS); Allison Owens of USDA's Farm Production and Conservation Business Center; and Tom Wirth and John Steller in EPA's Office of Atmospheric Programs (OAP) for their data, analysis, and review. Their thoughtful and diligent efforts compose the foundation of this report.

Sincerely,

William Hohenstein

Director, USDA Office of Energy and Environmental Policy, Office of the Chief Economist

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Glossary of Terms and Units

Chemical identities:

C	Carbon
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent
CH_4	Methane
N_2O	Nitrous oxide
NOx	Nitrogen oxides

Metric units:

MT	Metric ton (10^6 grams or 1,000 kg)
Mg	Megagram (10^6 grams)
Gg	Gigagram (10^9 grams)
Tg	Teragram (10^{12} grams)
MMT	Million metric tons (10^{12} grams)
ha	Hectares

Livestock specific:

B_0	Maximum methane-producing capacity of the volatile solids in manure
CEFM	Cattle Enteric Fermentation Model
DE	Digestible energy
MCF	Methane conversion factor
Nex	Total Kjeldahl nitrogen excretion rate
PRP	Pasture, Range and Paddock
TAM	Typical animal mass
VS	Volatile solids
WMS	Waste management system
Y_m	Fraction of gross energy converted to methane

Cropland specific:

ARMS	Agricultural Resource Management Survey
CRP	USDA Conservation Reserve Program
CEAP	Conservation Effects Assessment Project
DayCent	Daily Century biogeochemical model

Forestry specific:

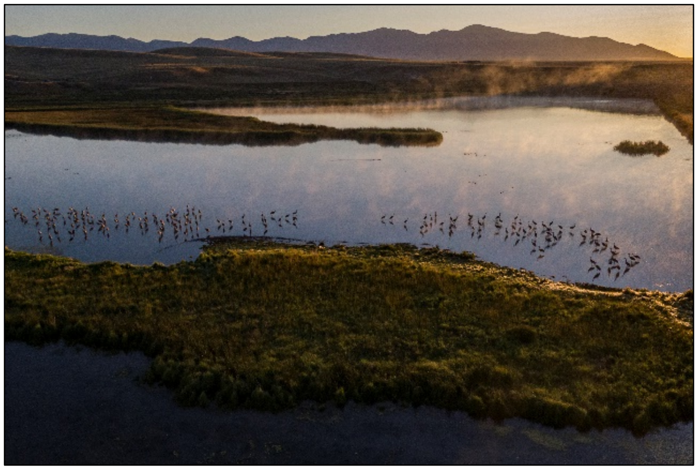
CRM	Component ratio method
dbh	Diameter breast height
FIA	USDA Forest Inventory and Analysis
FIADB	USDA Forest Inventory and Analysis Database
HWP	Harvested wood products
SOC	Soil organic carbon

Energy specific:

BTU	British thermal unit
QBTU	Quadrillion British thermal units
EIA	Energy Information Administration
eGRID	Emissions & Generation Resource Integrated Database by EPA
LP gas	Liquid petroleum gas

Other:

EF	Emission factor
GHG	Greenhouse gas
GWP	Global warming potential
LULUCF	Land Use, Land-Use Change, and Forestry
NRI	U.S. National Resources Inventory
PRISM	Parameter-elevation Relationships on Independent Slopes Model



Chapter 1: Introduction

Data from Chapter 1 can be downloaded from: http://dx.doi.org/10.15482/USDA.ADC/1524405

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1.1 Climate Change and Global Greenhouse Gas Emissions in Agriculture and Forestry

In 2018, total U.S. greenhouse gas emissions measured 6,676.6 million metric tons of carbon dioxide equivalents (MMT CO_2 eq.), rising 3.7 percent from 1990 estimates (EPA 2020). Global concentrations of the three most important long-lived greenhouse gases (GHG) in the atmosphere have increased measurably since the onset of the Industrial Revolution in 1750. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) concentrations in the atmosphere have increased by approximately 46 percent, 165 percent, and 23 percent respectively (EPA 2020, Keeling and Whorf 2005, Dlugokencky et al. 2005, Prinn et al. 2000). Agriculture and forestry practices can contribute to or remove GHGs from the atmosphere. Agriculture and forestry have contributed to GHGs in the atmosphere through cultivation and fertilization of soils, production of ruminant livestock, management of livestock manure, land-use conversions, and fuel consumption.

Table 1-1 Agriculture and Forestry Greenhouse Gas Emission Estimates and Uncertainty Intervals, 2018

	Estimate	Lower Bound	Upper Bound
Source	*MMT CO_2 eq.*		
Livestock	259	236	293
Crops[1]	251	117	384
Grassland[2]	89	(68)	241
On-Farm Energy Use[2]	79		
Forestry	(774)	(957)	(591)
Urban Trees[3]	(130)		
Net Emissions	**(227)**	**(545)**	**92**

Parentheses indicate a net sequestration. MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1]Includes C sequestration in agricultural soils.
[2]Includes CH_4 emissions from manure deposited on grasslands.
[3]Confidence intervals were not available for these components.

The primary GHG sources from agriculture are N_2O emissions from cropped and grazed soils, CH_4 emissions from ruminant livestock production and rice cultivation, CH_4 and N_2O emissions from managed livestock manure, and CO_2 emissions from on-farm energy use. The management of cropped, grazed, and forest land has helped offset GHG emissions by promoting the biological uptake of CO_2 through the incorporation of carbon into biomass, wood products, and soils, yielding net U.S. emissions of 5,903 MMT CO_2 eq. in 2018. Net emissions are total greenhouse gas emissions minus CO_2 sequestration, or removal of CO_2 from the atmosphere, including the forest sink and grazed lands and croplands soil sink (Table 1-2). This report estimates U.S. GHG emissions for the agricultural sector, quantifies uncertainty in emission estimates, and discusses strategies for agriculture to mitigate U.S. GHG emissions.

Observed increases in atmospheric GHG concentrations are primarily a result of fossil fuel combustion for power generation, transportation, and construction. In the United States, agriculture accounted for approximately 10 percent of total GHG emissions in 2018 (EPA 2020). Greenhouse gas emission estimates reported here are in units of CO_2 equivalents. Box 1-1 describes this reporting convention, which normalizes all GHG emissions to CO_2 equivalents using Global Warming Potentials (GWP). Agriculture in the United States, including livestock, grasslands, crop production, and energy use, contributed a total of 677 MMT CO_2 eq. to the atmosphere in 2018 (Table 1-1). This total includes a relatively small soil CO_2 sink of 2.0 and 13.4 MMT CO_2 eq. in cropped and grazed soils, respectively (Table 1-2). Forests, harvested wood products, and urban trees in the United States contributed to a total

Box 1-1

The USDA GHG Inventory report follows the international convention for reporting GHG emissions, as described in the introduction of the U.S. GHG Inventory (EPA 2020). Emissions of GHGs are expressed in equivalent terms, normalized to carbon dioxide (CO_2) using Global Warming Potentials (GWPs) published by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Table B1-1). GWPs, which are based on physical and chemical properties of gases, represent the effect of a given GHG on the climate, integrated over a given period of time, relative to CO_2 (IPCC 2006). Since the reference gas used is CO_2, GWP-weighted emissions are measured in million metric tons of CO_2 equivalent (MMT CO_2 eq.). GWP values allow for a comparison of the impacts of emissions and reductions of different gases. These values for methane (CH_4) and nitrous oxide (N_2O) are referenced to CO_2 and based on a 100-year time period (EPA 2020).

Table B1-1 (reproduced from U.S. GHG Inventory Report (EPA 2020), Table 1-2)

Gas	Atmospheric Lifetime	GWP[c]
CO_2	[b]	1
CH_4[a]	12	25
N_2O	114	298

Source: (IPCC 2013)
[a] The GWP of CH_4 includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.
[b] For a given amount of carbon dioxide emitted, some fraction of the atmospheric increase in concentration is quickly absorbed by the oceans and terrestrial vegetation, thus will continue to cycle through aquatic and terrestrial ecosystems as carbon. Some fraction of the atmospheric carbon dioxide will only slowly decrease over a number of years, and a small portion of the increase will remain for many centuries or more.
[c] 100-year time horizon.

The relationship between kilotons (kt) of a gas and MMT CO_2 eq. can be expressed as follows:

$$\text{MMT } CO_2 \text{ eq.} = (\text{kt of gas}) x (\text{GWP}) x (\text{MMT}/1000\text{kt})$$

where,
MMT CO_2 eq. = Million metric tons of CO_2 equivalent
kt = Kilotons (equivalent to a thousand metric tons)
GWP = Global warming potential
MMT = Million metric tons

reduction in atmospheric GHGs of approximately 904 MMT CO_2 eq. in 2018, which offset total U.S. GHG emissions by about 13 percent. After accounting for GHG sources and C sequestration, agricultural and forested lands in the United States were estimated to be a net sink of 227 MMT CO_2 eq. (Table 1-1). The 95-percent confidence interval for this estimate ranges from a sink of 92 to 545 MMT CO_2 eq. (Table 1-1).

A little over half (51 percent) of agriculture's GHG emissions in 2018 were from soils used for cropping and grazing (Figure 1-1). Most of the emissions from crop production were from non-rice soils, with residue burning and rice cropping accounting for about 2 percent of overall agricultural emissions (Figure 1-1). Enteric fermentation from livestock production was responsible for 26 percent of agricultural emissions. Managed livestock manure and on-farm energy use accounted for 12 and 11 percent of agricultural emissions, respectively. The estimates in Figure 1-1 are for emissions only, and do not account for C storage in agricultural soils and forests. Regarding sequestration, forests are by far the leading sink, followed by urban trees and harvested wood products (Figure 1-2).

Sources and sinks of emissions are partitioned in Figure 1-3 (sinks are values less than 0). Overall emissions profiles of agricultural sources, including energy use but excluding storage by soils and forestry, show that sources increased 11 percent between 1990

Table 1-2 Summary of Agriculture and Forestry Emissions and Removals, 1990, 1995, 2000, 2005, 2010, 2013–2018

Source	GHG	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
		MMT CO_2 eq.										
Livestock		**215.3**	**237.1**	**235.0**	**236.8**	**243.2**	**237.5**	**235.8**	**241.9**	**249.6**	**253.9**	**258.7**
Enteric Fermentation	CH_4	164.2	178.7	170.6	168.9	171.3	165.5	164.2	166.5	171.8	175.4	177.6
Managed Manure	CH_4	37.1	43.3	48.0	51.6	54.9	54.7	54.3	57.9	59.6	59.9	61.7
Managed Manure	N_2O	14.0	15.1	16.4	16.4	17.0	17.3	17.3	17.5	18.1	18.7	19.4
Grassland		**101.5**	**89.7**	**48.3**	**70.9**	**89.4**	**91.9**	**101.4**	**98.4**	**87.0**	**87.5**	**89.1**
Grassland	CH_4	3.2	3.5	3.2	3.3	3.2	2.9	2.8	3.0	3.1	3.2	3.1
Grassland	N_2O	95.8	95.3	87.1	97.2	101.5	103.4	103.7	104.9	99.0	98.3	99.4
Grassland	CO_2	2.4	(9.1)	(42.0)	(29.6)	(15.3)	(14.4)	(5.1)	(9.6)	(15.2)	(14.0)	(13.4)
Crops		**226.1**	**240.5**	**219.4**	**218.5**	**239.9**	**249.9**	**265.0**	**263.6**	**236.2**	**234.9**	**250.6**
Cropland Soils[1]	N_2O	220.1	217.8	207.2	215.8	222.6	236.1	245.5	243.2	230.8	229.1	238.8
Cropland Soils[2]	CO_2	(10.5)	5.8	(7.3)	(15.9)	(2.2)	(0.5)	3.5	3.7	(8.7)	(7.6)	(2.0)
Rice Cultivation	CH_4	16.0	16.5	19.0	18.0	18.9	13.8	15.4	16.2	13.5	12.8	13.3
Residue Burning	CH_4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Residue Burning	N_2O	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Energy Use[3]	CO_2	**66.5**	**83.4**	**77.2**	**71.2**	**73.6**	**73.9**	**67.3**	**70.0**	**95.0**	**78.2**	**78.7**
Forestry		**(939.7)**	**(924.0)**	**(885.8)**	**(906.2)**	**(859.7)**	**(895.0)**	**(858.8)**	**(917.1)**	**(898.3)**	**(888.1)**	**(903.7)**
Forests	CO_2	(719.5)	(708.4)	(682.0)	(682.8)	(666.6)	(684.4)	(643.4)	(698.0)	(676.1)	(662.6)	(675.1)
Harvested Wood	CO_2	(123.8)	(112.2)	(93.4)	(106.0)	(69.1)	(82.6)	(86.0)	(88.7)	(92.4)	(95.7)	(98.8)
Urban Trees[4]	CO_2	(96.4)	(103.4)	(110.4)	(117.4)	(124.0)	(128.0)	(129.4)	(130.4)	(129.8)	(129.8)	(129.8)
Total Emissions	**All GHGs**	609.4	650.6	579.8	597.4	646.2	653.2	669.5	673.9	667.7	654.5	677.2
Net Emissions	**All GHGs**	**(330.3)**	**(273.4)**	**(306.0)**	**(308.9)**	**(213.5)**	**(241.9)**	**(189.3)**	**(243.2)**	**(230.6)**	**(233.6)**	**(226.5)**

Note: Parentheses indicate a net sequestration. MMT CO_2 eq. is million metric tons carbon dioxide equivalent. CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide.
[1]Includes emissions from managed manure during storage and transport before soil application.
[2]Includes soil organic C stock changes from land set aside under the USDA Conservation Reserve Program and cultivated mineral and organic soils as well as emissions from liming and urea fertilizer additions.
[3]Data extrapolated from energy use (table 5.2) for all years except for inventory reported years 2005, 2013, and 2018.
[4]Data taken from EPA. Not reported for years 1991–2004 and 2006–2013. Data interpolated for unreported years.

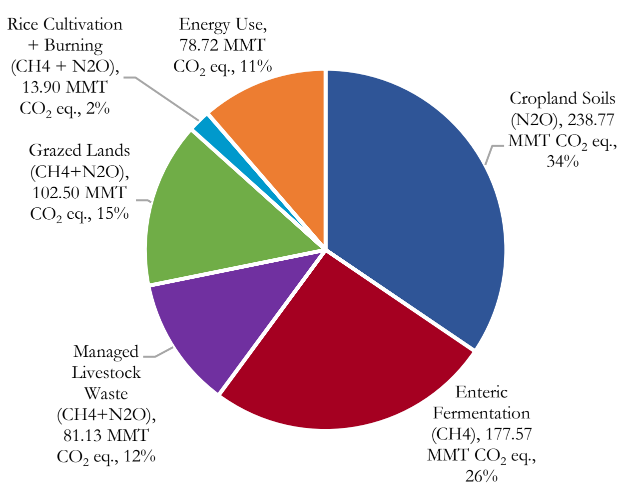


Figure 1-1 Agricultural Sources of Greenhouse Gas Emissions in 2018
CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide. MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

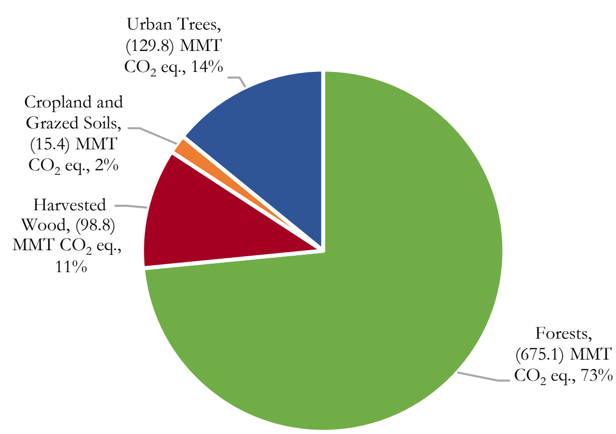


Figure 1-2 Agricultural and Forest Sinks of Carbon Dioxide in 2018
(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

(baseline year) and 2018 (Table 1-2, Figure 1-3). The sink strength of the forests, harvested wood, and urban trees pool has decreased 4 percent since 1990 (Table 1-2, Figure 1-3). However, the sink strength of agricultural soils has almost doubled since 1990. In sum, emissions increased from 1990 to 2018, while carbon storage related to forestry decreased over the same period. Because carbon sequestration exceeds sources across the full timeseries, net emissions are negative (GHG sink); however, the amount of annual net sequestration decreased by about 31 percent since 1990 (Table 1-2).

Annual CO_2 emissions from on-farm energy use in agriculture are small relative to total energy use across all sectors in the United States. In 2018, fuel and electricity consumption associated with crop and livestock operations resulted in 78.7 MMT CO_2 (Table 1-2), which equals 1.4 percent of overall energy-related CO_2 emissions for the United States in 2018 (5249.3 MMT CO_2, EPA 2020). Diesel fuel use accounted for 48 percent of CO_2 emissions from energy use in agriculture, while electricity use, gasoline, liquefied petroleum gas, and natural gas contributed 31 percent, 10 percent, 7 percent, and 4 percent, respectively.

1.2 Sources, Sinks, and Mechanisms for Greenhouse Gas Emissions

Greenhouse gases are emitted from both natural and managed systems. At the global scale, about one-half to two-thirds of annual CH_4 emissions and roughly a third of global annual emissions of N_2O are believed to derive from human sources with agriculture being the primary anthropogenic source (IPCC 2013). In the United States, agriculture is responsible for about 40 percent of anthropogenic CH_4 and 80 percent of anthropogenic N_2O. Agricultural activities contribute to these emissions in several ways. While losses of N_2O to the atmosphere occur naturally, the application of nitrogen to amend soil fertility increases the rate of emissions. The rate is amplified when more nitrogen is applied than can be used by the plants, either due to volume or timing. In agricultural practices, nitrogen is added to soils through the use of synthetic fertilizers, application of manure, cultivation of nitrogen-fixing crops/forages (e.g., legumes), and retention of crop residues. Rice cultivation involves periodic flooding of rice paddies, which promotes anaerobic decomposition of organic matter (rice or previous crop residue and organic fertilizers) by soil microbes, resulting in methane emissions. Finally, burning of residues in agricultural fields produces CH_4 and N_2O as combustion byproducts. Although CO_2 is also a combustion byproduct, it is assumed that these emissions are balanced by CO_2 uptake while plants are growing so the net impact is neutral.

Livestock grazing, production, and manure emit CH_4 and N_2O into the atmosphere. Ruminant livestock such as cattle, sheep, and goats emit CH_4 as a byproduct of their digestive processes (called enteric fermentation). Managed livestock manure can release CH_4 through the biological breakdown of organic compounds and N_2O through nitrification and denitrification of nitrogen contained in manure; the magnitude of emissions depends in large part on animal populations, manure management practices and to some degree on the energy content of livestock feed. Nitrous oxide emissions from grazed lands are increased through nitrogen in manure and urine deposited by grazing animals (designated Pasture, Range, and Paddock manure) and from biological fixation of nitrogen by legumes, which are typically seeded in heavily grazed pastures. Some pastures are also amended with nitrogen fertilizers, managed manure, and biosolids, which also contribute to GHG emissions on those lands.

Agricultural and forest systems can be sources or sinks of CO_2. For example, land use conversion involving burning of biomass directly releases CO_2 while draining organic soils for cropping or grazing enhances soil decomposition rates which also results in CO_2 release. In contrast, C storage in growing forests acts as a CO_2 sink. The net flux of CO_2 between the land and the atmosphere is a balance between carbon losses from land use conversion and land management practices, and carbon gains from forest growth and sequestration in soils (IPCC 2001).

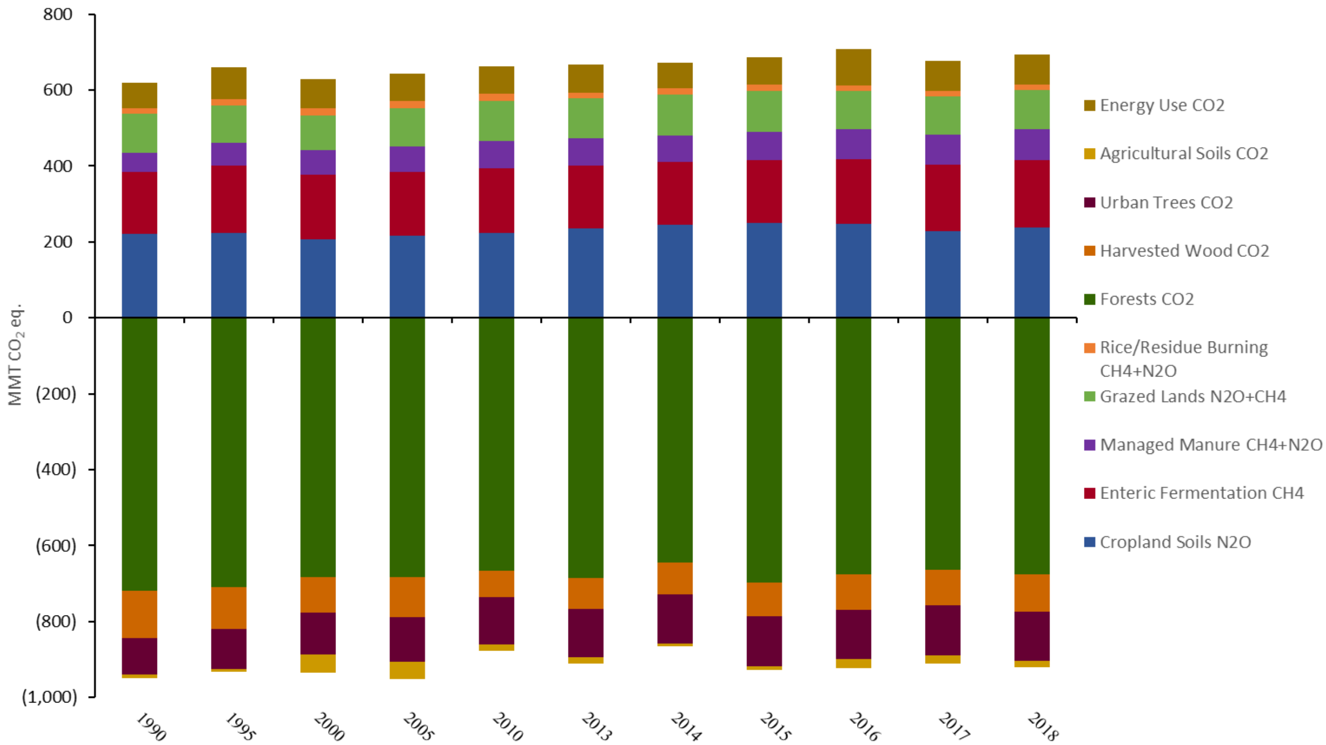


Figure 1-3 Agriculture and Forestry Emissions and Removals for 1990, 1995, 2000, 2005, 2010, 2013–2018
(MMT CO2 eq. is million metric tons of carbon dioxide equivalent)

1.3 Strategies for Greenhouse Gas Mitigation

Enhancing carbon sinks, also referred to as carbon sequestration, is achieved by increasing capacity for carbon uptake and storage in biomass, wood products, and soils. Agriculture and forest management can mitigate the buildup of greenhouse gases in the atmosphere by reducing emissions or enhancing carbon sinks. Improved forest regeneration and management practices such as density control, nutrient management, and genetic tree improvement promote tree growth and enhance carbon accumulation in biomass. In addition, wood products harvested from forests can serve as long-term carbon storage pools. The adoption of agroforestry practices, like windbreaks and riparian forest buffers which incorporate trees and shrubs into ongoing farm operations, represents a potentially large GHG sink nationally. While deforestation is a large global source of CO_2, within the United States, net forestland area has experienced a relatively small net loss in recent decades ranging from a maximum of about 5.5 million hectares per year in the 1990s (mainly due to increased insect mortality) to a current loss of about 2.3 million hectares per year in the 2000s (Zhang et al. 2012). Avoidance of large-scale deforestation and adoption of the practices mentioned above have resulted in the forestry sector being a net GHG sink in the United States. This sink could be increased by increasing afforestation and implementing more intensive management to increase forest growth (McKinley et al. 2011).

Agricultural practices such as conservation tillage and grassland practices such as rotational grazing can also reduce carbon losses and promote carbon sequestration in agricultural soils. These practices offset CO_2 emissions caused by land-use activities such as conventional tillage and cultivation of organic soils. However, strategies intended to sequester carbon in soils can also impact the fluxes of two important non-CO_2 GHGs, N_2O and CH_4. Consequently, the net impact of different management strategies on all three GHGs must be considered when comparing alternatives (Robertson et al. 2000, Del Grosso et al. 2005).

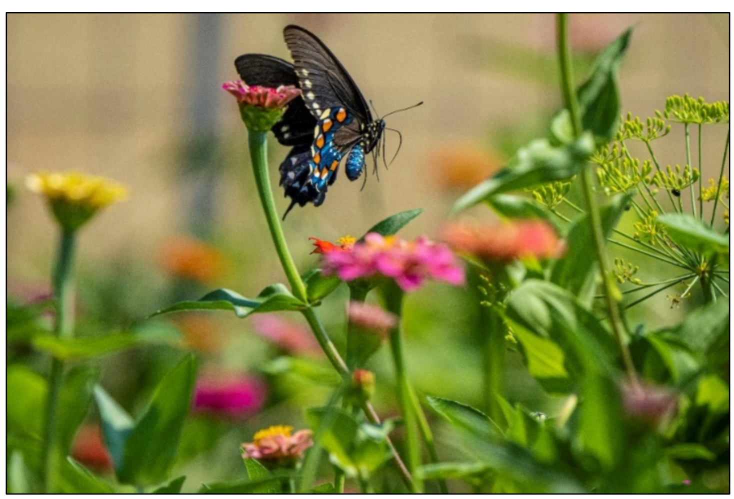
Innovative practices to reduce GHG emissions from livestock include modifying the energy content of livestock feed, inoculating feed with agents that reduce CH_4 emissions from digestive processes, improving supply chain management to utilize feed ingredients with a lower GHG profile, and managing manure in controlled systems that reduce or eliminate GHG emissions. For example, anaerobic digesters are a promising technology, whereby CH_4 emissions from livestock manure is captured and used as an alternative energy source. Nitrous oxide emissions from soils can be reduced by precision application of nitrogen fertilizers and use of enhanced efficiency fertilizers such as those formulated with nitrification inhibitors. Additional USDA reports (Eve et al. 2014) discuss these and other mitigation options in detail and quantify expected GHG reductions (or increases) for various land management practices (Eve et al. 2014, ICF International 2013, Pape et al. 2016).

1.4 Purpose of This Report

The U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990–2018 was developed to update the *U.S. Agriculture and Forestry Greenhouse Gas Inventories: 1990–2001* (USDA 2004), *1990–2005* (USDA 2008), *1990–2008* (USDA 2011), and *1990–2013* (USDA 2016) and to revise estimates for previous years based on improved methodologies. This inventory provides a comprehensive assessment of the contribution of U.S. agriculture (i.e., livestock and crop production) and forestry to greenhouse gas emissions. The document was prepared to support and complement information provided in the official *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (U.S. GHG Inventory), which is prepared annually by the U.S. Environmental Protection Agency to meet U.S. commitments under the United Nations Framework Convention on Climate Change (EPA 2020). This report, the *U.S. Agriculture and Forestry Greenhouse Gas Inventory* (USDA GHG Inventory), supplements the U.S. GHG Inventory, providing an indepth look at agriculture and forestry emissions and sinks of GHG and presenting additional information on GHG emissions from fuel consumption on U.S. farms.

The U.S. GHG Inventory provides national-level estimates of emissions of the primary long-lived GHGs (carbon dioxide, methane, nitrous oxide, and fluorinated gases) across a broad range of sectors (Energy; Industrial Processes and Product Use; Waste; Agriculture; and Land Use, Land-Use Change and Forestry). This format is designed to serve the needs of land managers, planners, and others with an interest in greenhouse gas dynamics and their relationships to land use and land-use change. Due to the requirements for national-level reporting in the U.S. GHG inventory, that report does not always provide regional or State GHG emissions data. However, in some cases State and regional emissions data are part of the inventory development process and can be used for more disaggregated analyses. Whenever possible, emissions data reported in this edition of the USDA Inventory are disaggregated at the State level. Emissions are categorized by additional information such as land ownership and management practices.

Emissions reported here do not always exactly match the emissions reported in the U.S. GHG Inventory (EPA 2020) for some source categories. There are two main reasons for this; first the EPA (2020) report partitions emissions by IPCC (2006) categories, while the USDA report attempts to designate emissions due to agricultural production systems. For example, EPA (2020) includes emissions associated with C stock changes in cropped and grazed soils in the land use, land-use change, and forestry (LULUCF)category, whereas emissions from these sources are included in the agricultural soils category in this report. Second, in some tables and figures EPA (2020) reports CO_2 emissions from energy (e.g., electric power generation) partitioned as its own category. In contrast, this report explicitly accounts for CO_2 emissions from on-farm energy use in the agricultural sector. Note that this report does not account for CO_2 emissions from indirect energy, which is defined as energy used off the farm to manufacture farm inputs such as synthetic fertilizers. The emissions estimates from on-farm energy use in the agricultural sector were prepared separately from the U.S. GHG Inventory. This report customizes the data from the U.S. GHG Inventory in a manner that is useful to agriculture and forestry producers and related industries, natural resource and agricultural professionals, as well as technical assistance providers, researchers, and policymakers. The information provided in this inventory is useful in improving our understanding of the magnitude of GHG emissions by State, region, and land use, and by crop, pasture, range, livestock, and forest management systems. The analyses presented in this report are the result of a collaborative process and direct contributions from EPA, USDA (Forest Service, Natural Resources Conservation Service, Agricultural Research Service, Office of Energy and Environmental Policy), the Natural Resources Ecology



Laboratory (NREL) of Colorado State University, and Eastern Research Group (ERG).

USDA administers a portfolio of conservation programs that have multiple environmental benefits including reductions in GHG emissions and increases in carbon sequestration. This and future USDA GHG Inventory reports will facilitate tracking progress towards promoting carbon sequestration and reducing GHG emissions through agriculture and forest management. The USDA GHG Inventory describes the role of agriculture and forestry in GHG emissions and sinks. Extensive and indepth emissions estimates are presented for all agricultural and forestry GHG sources and sinks for which internationally recognized methods are available. This report:

- Quantifies current levels of emissions and sinks at State, regional, and national scales in agriculture and forestry,
- Identifies activities and trends that are driving GHG emissions and equestration,
- Quantifies the uncertainty associated with GHG emission and sequestration estimates.

1.5 Overview of the Report Structure

The report provides estimates and trends in agriculture and forestry GHG emissions and sinks, with information at State and regional levels. The report is structured from a land-use perspective, addressing livestock operations, croplands, and forests separately. It also includes a chapter on energy use. The livestock chapter includes GHG emissions from livestock and livestock manure from confined livestock operations as well as pasture and range operations and manure deposited by grazing livestock. The cropland agriculture chapter addresses emissions from cropland soil amendments, rice production, and residue burning, as well as carbon sequestration in agricultural soils. The forest chapter details carbon sequestration in forest biomass and soils, urban trees, and wood products. Fluxes of CH_4 and N_2O in forestry are estimated for 2018 but are not addressed across the timeseries. Forest soils are net CH_4 sinks in the United States, and soil N_2O emissions are small because forests do not receive large N additions. The energy chapter provides information on CO_2 emissions from energy consumption on U.S. farms, covering GHG emissions from fuel use in livestock and cropland agriculture. While the U.S. GHG Inventory provides estimates of GHG emissions from energy consumption in the production of fertilizer, this upstream source of agricultural GHG emissions is not covered in this report.

Livestock and grazed land, cropland agriculture, forestry, and energy use are addressed in Chapters 2 through 5. A summary of GHG emissions at the national level is provided in each chapter, followed by more detailed descriptions of emissions by each source at national and subnational scales. Methodologies used to estimate GHG emissions and quantify uncertainty are summarized. Changes from the previous edition of this inventory are indicated. Text describing the methods and uncertainty for some chapters is summarized from the U.S. GHG Inventory, with cooperation from the EPA.

1.6 Summary of Changes and Additions for the 5th Edition of the Inventory

This edition of the U.S. Agriculture and Forestry Greenhouse Gas Inventory integrates improvements that were implemented in successive editions of the Inventory of U.S. Greenhouse Gas Emissions and Sinks. When adjustments are made to existing methodologies (e.g., using higher Tier methods for a larger portion of the land base), recalculations are made for the entire time series of estimates to ensure consistency. In addition to updating GHG flux estimates for 1990–2013 (based on current methodologies), estimates for 2014–2018 are also included.

Major changes impacting livestock emissions involved revising animal population and weight estimates or diet assumptions, refining the models used to calculate emissions, and using updated activity data (see Chapter 2 for details). Manure management system data for dairy and swine were also updated. As a result of these changes, emissions from manure management decreased on average 4.0 percent and enteric fermentation by 0.1 percent for the years 1990 through 2013 as compared to the previous inventory (USDA 2016).

Agricultural soil emissions estimates for N_2O, CH_4, and CO_2 were improved by the development of an imputation analysis, which was generated by combining information from the 2003–2006 USDA-NRCS Conservation Effects Assessment Project (CEAP) survey, with data from USDA-ERS Agricultural Resource Management Surveys (ARMS), Conservation Tillage Information Center (CTIC) surveys, ERS cropping surveys and USDA Census of Agriculture data. These data were used to fill gaps in USDA cropland management data by simulating management activity data from 1980 to 2015, creating a detailed and consistent time series for the inventory.

Other improvements include refinements to Daily Century (DayCent) model structure and parameterization, one of the most important being an enhancement to represent spring thaw related N_2O emissions. These changes and updates resulted in an approximate 10-percent increase in N_2O emissions from grazed lands on average for 1990 to 2013 and a 110-percent increase in the grazed lands carbon sink. In cropland soils, the use of updated time series and DayCent model improvements resulted in a 35-percent increase in N_2O emissions, relative to the previous inventory, and an average annual decrease in soil organic carbon storage of approximately 3 MMT CO_2. Methane emissions from rice cultivation were estimated using Tier 3 DayCent methods, an improvement over the Tier 2 methods used in the last report and increased by about 85 percent as a result.

The forestry carbon sink estimates reflect numerous incremental improvements in methods, models, and data between the 2015 U.S. GHG Inventory (EPA 2015) and the 2020 U.S. GHG Inventory (EPA 2020) in terms of net stock change since 1990. New annual inventory data and adjustments to the land area classified as forests have affected stock totals and changes. In addition, major changes in carbon conversion factors affected estimates as each update was implemented. These changes increased overall forestry carbon stock change estimates by about 14 percent relative to the previous inventory.

For the calculation of CO_2 emissions from on-farm energy use in the agricultural sector, the following changes have been applied in comparison to previous editions: i) commercial electricity and natural gas prices are used instead of residential electricity prices, providing a more realistic representation for energy use; ii) the CO_2 emission estimates from electricity generation are calculated based on the national and State annual CO_2 total output emission rate (lb/MWh) available from EPA's Emissions & Generation Resource Integrated Database (eGRID) (EPA 2020b); iii) Updates to CO_2 emissions from on-farm energy use between 1990 and 2018 were extrapolated from energy use for all years when the inventory was not published providing more realistic fluctuations over time.

Aggregating across all sources and sinks, emissions reported in this inventory remain a net sink for the sector, but the estimated sink strength is on average about 10 percent higher. Although some of the changes compared to the previous inventory may appear to be large, they are within the calculated uncertainty ranges. Because of the relatively large uncertainty associated with GHG fluxes for agricultural and forestry production systems it is not surprising that emission estimates vary between inventories. However, both the observational measurements that are used to test and constrain the methods and models used, and the estimates derived from the methods and models, should improve as more extensive observational data sets become available. Similarly, availability of more refined model input data sets should improve the estimates reported in future editions of this volume. The individual chapters provide details regarding expected improvements for major source categories.

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Chapter 2: Livestock and Grazed Land Emissions

Data from Chapter 2 can be downloaded from: http://dx.doi.org/10.15482/USDA.ADC/1524406

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2.1 Summary of U.S. Greenhouse Gas Emissions From Livestock

A total of 345 MMT CO_2 eq. of greenhouse gases (GHGs) were emitted from livestock including enteric fermentation, managed livestock manure (includes solid and liquid waste), and grazed land in 2018 (Table 2-1). This represents about 56 percent of total emissions from the agricultural sector, which totaled 618.5 MMT CO_2 eq. (EPA 2020).

Table 2-1 Greenhouse Gas Emission Estimates and Uncertainty Intervals in 2018

Source	Estimate	Lower Bound	Upper Bound
		MMT CO_2 eq.	
CH_4 enteric fermentation	178	158	210
CH_4 managed manure + grazed land	62	51	74
N_2O managed manure	19	16	24
N_2O grazed land	99	60	142
CO_2 grazed land remaining grazed land	11	(134)	157
CO_2 land converted to grazed land	(25)	(59)	9
Total	**345**	**189**	**504**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

Compared to the base year (1990), emissions from livestock sources were about 10 percent higher in 2018. There are three main sources of increased emissions: methane (CH_4) and nitrous oxide (N_2O) emissions from managed livestock manure and N_2O emissions from grazed lands. These increases were partially offset because the CO_2 sink strength of grazed lands increased. The 95-percent confidence interval for 2018 was estimated to lie between 189 and 504 MMT CO_2 eq. (Table 2-1).

Enteric fermentation contributed a little more than half (178 MMT CO_2 eq.) of all emissions associated with livestock production, while soils from grazed lands (89 MMT CO_2 eq.) and managed manure (81 MMT CO_2 eq.) accounted for approximately 26 percent and 23 percent, respectively, of the total livestock emissions. All of the emissions from enteric fermentation and about 76 percent of emissions from managed livestock manure were in the form of CH_4. Of the emissions from grazed lands, 87 percent[1] were in the form of N_2O from soils (Table 2-1). Soils in grazed lands do not often experience the anaerobic conditions required for CH_4 production to exceed CH_4 uptake. However, a small portion of manure from grazing animals is converted to CH_4 during the short period of time when deposited manure is drying. Lands converted to grazing are estimated to be a C sink, and this sink exceeds the losses of C from long-term grazed lands even with the losses of biomass C from deforestation with conversion of forest land to grazed land. Grazed lands are estimated to be a small CO_2 overall sink at 13.4 MMT CO_2 eq. in 2018 (Table 2-1). Note that the uncertainty ranges for grazed land remaining grazed land and land converted to grazed land have lower bounds indicating sequestration and upper bounds indicating emissions (Table 2-1).

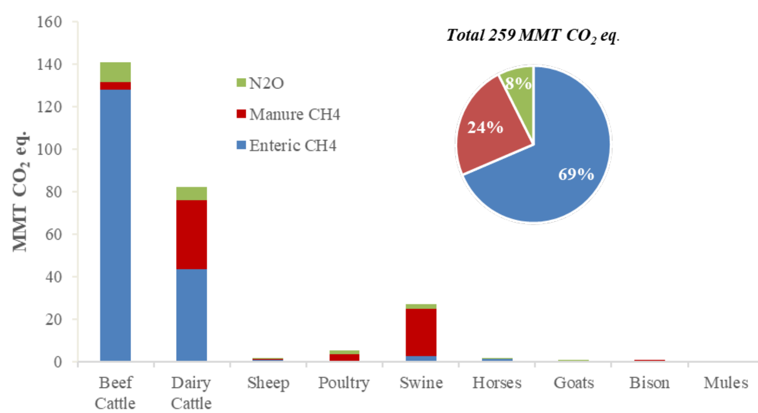


Figure 2-1 Greenhouse Gas Emissions From Livestock in 2018
(CH4 is methane; N2O is nitrous oxide. MMT CO2 eq. is million metric tons of carbon dioxide equivalent)

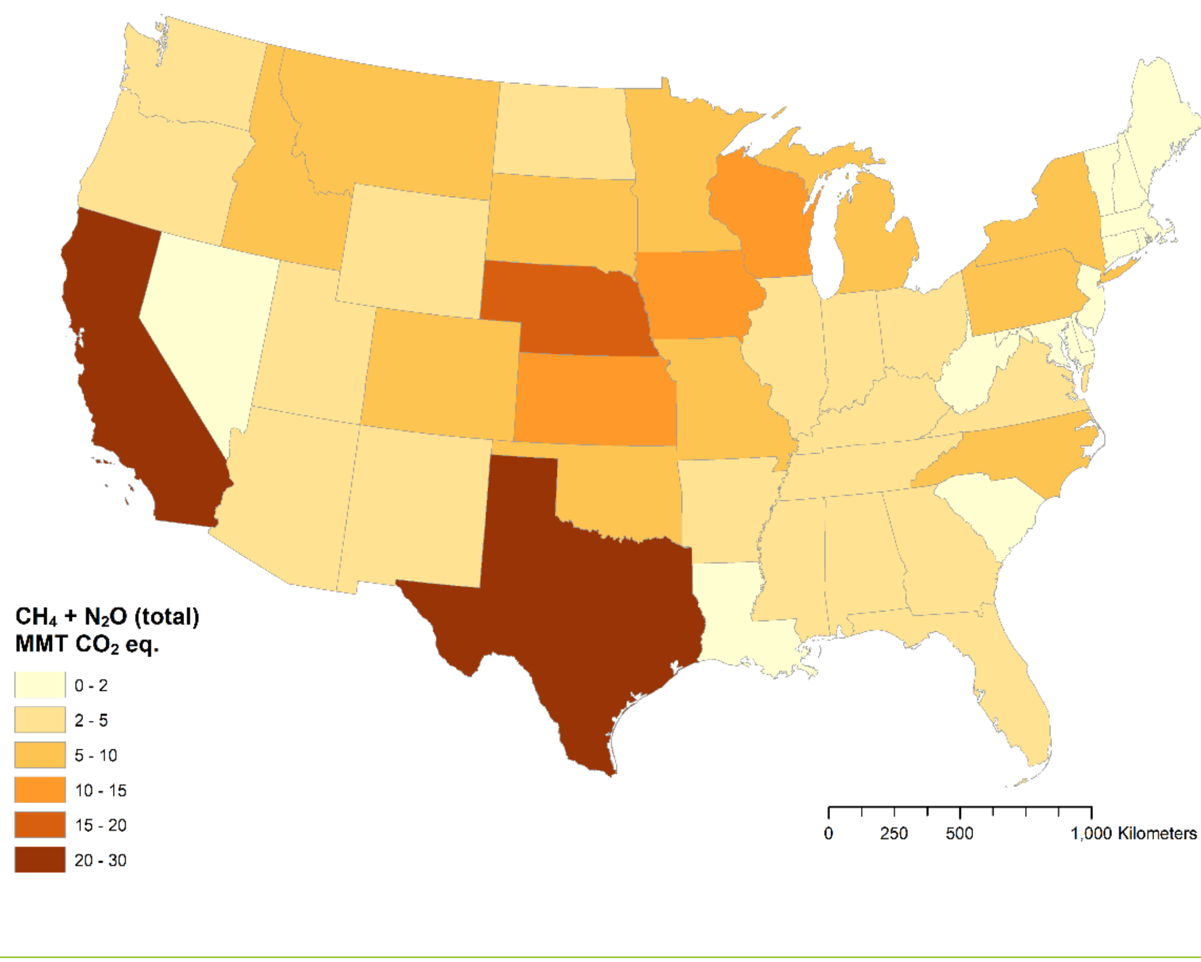
[1] This estimate only includes emissions and not the uptake of greenhouse gases associated with land converted to grazed land.

Figure 2-1 and Map 2-1 present a subset of total emissions from livestock production by animal type and gas and by State, respectively. The largest total emissions associated with livestock production were from Texas and California (Map 2-1). Emissions were high in Texas primarily because of the large numbers of beef cattle, while dairy cattle emissions are responsible for most emissions in California. Emissions were also over 10 MMT CO_2 eq. in Nebraska, Kansas, Wisconsin, Iowa, and Missouri. Soil N_2O only includes the portion of total gas flux associated with N inputs from manure for each animal type and CO_2 emissions were not partitioned because there is not a reliable method.

Beef cattle contributed the largest fraction (55 percent) of GHG emissions from livestock in 2018, with the majority of emissions in the form of CH_4 from enteric fermentation and N_2O from grazed land soils (Figure 2-1, Table 2-2). Dairy cattle were the second-largest livestock source of GHG emissions (31 percent), primarily CH_4 from enteric fermentation and managed manure. The third-largest GHG source from livestock was swine (10 percent), nearly all of which was CH_4 from manure. Horses, mules, goats, sheep, and bison caused small GHG emissions when compared to other animal groups because populations of these types are relatively small. Poultry have relatively low emissions, despite being the largest livestock group in number of animals, because this group produces very low enteric fermentation emissions.

Livestock contribute GHGs to the atmosphere both directly and indirectly. Livestock emit CH_4 directly as a byproduct of digestion through a process called enteric fermentation. In addition, livestock manure and urine (manure) cause CH_4 and N_2O emissions to the atmosphere through increased decomposition and nitrification/denitrification, as well as run off and leaching (indirect emissions). Managed manure that is collected and stored emits CH_4 and N_2O throughout its lifecycle. Grazing animals influence soil processes (e.g., nitrification/denitrification) that result in N_2O emissions from the nitrogen in their manure. Forage legumes on grazed lands also contribute to N_2O emissions because when legumes fix nitrogen from the

Map 2-1 Greenhouse Gas Emissions From Livestock Production in 2018.
(CH_4 is methane; N_2O is nitrous oxide; MMT CO_2 eq. is million metric tons of carbon dioxide



atmosphere, that N can become mineralized in the soil and contribute to nitrification and denitrification. Grazed lands can also act as a source or sink for atmospheric carbon dioxide (CO_2). The following sections describe these sources and contributing processes in detail.

Table 2-2 Greenhouse Gas Emissions by Livestock Category and Source in 2018

	Enteric Fermentation	Managed Livestock Manure		Grazed Land		*Total*
	CH_4	CH_4	N_2O	N_2O[1]	CH_4	
Animal Type			*MMT CO_2 eq*			
Beef Cattle	128.13	3.38	9.23	10.94	2.71	**154.39**
Dairy Cattle	43.60	32.29	6.13	1.02	0.25	**83.30**
Swine	2.77	22.21	2.00	0.04	0.01	**27.02**
Horses	1.21	0.18	0.09	0.31	0.08	**1.87**
Poultry	NA	3.52	1.66	0.02	0.00	**5.20**
Sheep	1.05	0.07	0.31	0.09	0.02	**1.55**
Goats	0.34	0.02	0.02	0.08	0.02	**0.49**
American Bison	0.39	0.01	NA	0.05	0.01	**0.45**
Mules and Asses	0.08	0.01	0.00	0.01	0.00	**0.11**
Total	177.6	61.7	19.4	12.6	3.1	**274.4**

[1]Only N_2O emissions resulting from PRP (Pasture, Range, and Paddock) N inputs are included here.

This chapter provides national and State-level data on CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from managed livestock manure, and CO_2, N_2O, and CH_4 fluxes for grazed lands. Emissions associated with both PRP (Pasture, Range, and Paddock) manure deposited by grazing livestock and managed manure applied to grazed land are included in this chapter, while nitrous oxide emissions from managed livestock manure applied to cropland soils are included in the Cropland Agriculture chapter (Chapter 3). State-level livestock population data also are presented in this chapter because GHG emissions from livestock are related to livestock population sizes.

2.2 Sources of Greenhouse Gas Emissions From Livestock

The mechanisms and important factors that generate GHG fluxes from livestock, manure management, and grazed lands are detailed below.

2.2.1 Enteric Fermentation

Enteric fermentation is a normal digestive process in animals where anaerobic microbial populations in the digestive tract ferment food and produce CH_4 gas as a byproduct. Methane is then emitted from the animal to the atmosphere through exhaling or eructation.

Ruminant livestock—including cattle, sheep, and goats—have greater rates of enteric fermentation because of their unique digestive system, which includes a large rumen or fore-stomach where enteric fermentation takes place. Non-ruminant livestock such as swine, horses, and mules produce less CH_4 because enteric fermentation takes place in the large intestine, which has a smaller capacity to produce CH_4 than the rumen. The energy content and quantity of animal feed also affect the amount of CH_4 produced in enteric fermentation, with lower quality and higher quantities of feed causing greater emissions. Low quality feeds, such as dormant grasses and crop residues, are relatively low in protein and high in fiber which reduces digestibility and enhances CH_4 production.

2.2.2 Managed Livestock Manure

Livestock manure can be managed in storage and treatment systems or spread on fields in lieu of long-term storage. Alternatively, livestock manure is termed unmanaged when it is deposited directly on grazed lands and not transported. Many livestock producers in the United States manage livestock manure in systems such as solid storage, dry lots, liquid/slurry storage, deep pit storage, and anaerobic lagoons. Table 2-3 (adapted from EPA 2020) provides descriptions of managed and unmanaged pathways for livestock manure, indicating the relative impacts of different pathways on GHG emissions. Sometimes livestock manure that is stored and treated is subsequently applied as a nutrient amendment to agricultural soils. GHG emissions from treated manure applied to cropland soils as a nutrient amendment are discussed in the next chapter along with GHG emissions from other nutrient amendments for crop production.

The magnitude of CH_4 and N_2O emissions from managed livestock manure depends in large part on the storage system and environmental conditions. Methane is emitted under anaerobic conditions, when oxygen is not available to the bacteria that decompose manure. Storage in ponds, tanks, or pits such as those that are coupled with liquid/slurry flushing systems often promote anaerobic conditions (i.e., where oxygen is not available and CH_4 is produced), whereas solid manure stored in stacks or shallow dry pits tends to provide aerobic conditions (i.e., where oxygen is available and little or no CH_4 is produced). However, moist conditions (which are a function of rainfall and

Table 2-3 Descriptions of Livestock Manure Deposition and Storage Pathways

Manure Management System	Description
Pasture/Range/Paddock	Manure and urine from pasture and range grazing animals are deposited directly onto the soil and is not managed.
Daily Spread	Manure and urine are routinely collected and spread on fields within 24 hours of excretion; there is little or no storage of the manure/urine before it is applied to soils.
Solid Storage	Manure and urine (with or without litter) are collected by some means and placed under long-term bulk storage.
Dry Lot	Manure and urine are deposited directly onto a paved or unpaved open containment area where the manure is allowed to dry and it is periodically removed (after removal, it is sometime spread onto fields).
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water to facilitate handling and is stored in either tanks or earthen ponds, usually for periods less than one year.
Anaerobic Lagoon	Uncovered anaerobic lagoons are designed and operated to combine manure stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors, and must be cleaned out every 5–15 years, and the sludge is typically applied to agricultural lands. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields. Lagoons are sometimes used in combination with a solids separator, typically for dairy manure. Solids separators help control the buildup of non-degradable material such as straw or other bedding materials.
Anaerobic Digester	Animal excrement with or without straw is collected and anaerobically digested in a large containment vessel (complete mix or plug flow digester) or covered lagoon. Digesters are designed and operated for manure stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which are captured and flared or used as a fuel.
Deep Pit	Combined storage of manure and urine in pits (up to one year) below livestock confinements. Little to no water added to manure.
Poultry With Litter	Enclosed poultry houses use bedding derived from wood shavings, chopped straw, or other products depending on availability. The bedding absorbs moisture and dilutes manure. Litter is cleaned out once a year. This system is used for breeder flocks and meat chickens (broilers) and other fowl.
Poultry Without Litter	In high-rise cages or scrape-out/belt systems, manure is excreted onto the floor below with no bedding to absorb moisture. The ventilation system dries the manure as it is stored. This high-rise system is a form of passive windrow composting.

Adapted from IPCC 2006; EPA 2020.

humidity) can promote CH_4 production in non-liquid-based manure systems. High temperatures generally accelerate the rate of decomposition of organic compounds in manure, increasing CH_4 emissions under anaerobic conditions. In addition, longer residency time in a storage system can increase CH_4 production, and added moisture, particularly in solid storage systems that normally experience aerobic conditions, can amplify CH_4 emissions.

While storage system and environmental conditions are important factors affecting CH_4 emissions from the management of livestock manure, diet and feed characteristics are also influential. Livestock feed refers to the mixture of grains, hay, and byproducts from processed foods that is fed to animals at feedlots and as supplemental feed for grazing animals, while diet includes the mixture of plants that animals graze. Livestock feed, diet, and growth rates affect both the amount and quality of manure. Not only do greater amounts of manure lead to higher CH_4 production, but higher energy feed also produces manure with more volatile solids, increasing the substrate from which CH_4 is produced. However, this impact is somewhat offset because some higher energy feeds are more digestible than lower quality forages, and thus less manure is excreted.

The production of N_2O from managed livestock manure depends on the composition of the manure, the type of bacteria involved, and the conditions following excretion. For N_2O emissions to occur, the manure must first be handled aerobically where ammonia or organic nitrogen is converted to nitrates and nitrites (nitrification), and if conditions become sufficiently anaerobic, nitrates and nitrites can be denitrified, i.e., reduced to N oxides and nitrogen gas (N_2) (Groffman et al. 2000; Robertson and Groffman 2015). Nitrous oxide is produced as an intermediate product of both nitrification and denitrification and can be directly emitted from soil as a result of both of these processes. These emissions are most likely to occur in dry-manure handling systems that have aerobic conditions but that also contain pockets of anaerobic conditions due to high water content and high oxygen gas (O_2) demand from decomposition. For example, manure in dry lots is deposited on soil, oxidized to nitrite and nitrate, and encounters anaerobic conditions following precipitation events that increase water content, enhance decomposition, and deplete the supply of O_2.

Managed livestock manure can also contribute to indirect N_2O emissions. Indirect emissions result from nitrogen that was volatilized or leached/run off from the manure management system in a form other than N_2O and was then converted to N_2O offsite. These sources of indirect N_2O emission from animal manure are from ammonia (NH_3) volatilization and nitrate (NO_3) run off into ground or surface waters. The gaseous losses of NH_3 to the atmosphere can then be deposited to the soil and converted to N_2O by nitrification. The nitrate run off into waterways can be converted to N_2O by aquatic denitrification. Note that in addition to NH_3 losses, NO_x can contribute to volatilization but because there are no quantified estimates available, losses due to volatilization are based solely on NH_3 loss factors. Similarly, leached NO_3 can contribute to indirect N_2O, but because little is known about leaching from manure management systems, only emissions associated with run off are calculated.

2.2.3 Grazed Lands

Nitrous oxide from soils is the primary GHG associated with grazed lands. Grazed lands contribute to N_2O emissions by adding nitrogen to soils from animal manure and urine, forage legumes, and fertilizer additions, which is cycled into the soil and provides substrates for nitrification and denitrification. Nitrous oxide is a byproduct of this cycle; thus, more nitrogen added to soils yields more N_2O released to the atmosphere. A portion of the nitrogen cycled within the plant-animal-soil system volatilizes to the atmosphere in various gaseous forms and is eventually re-deposited onto the soils where it can contribute to indirect N_2O emissions. Some nitrogen in the form of nitrate can leach into groundwater and surface run off, undergo denitrification, and contribute to indirect N_2O emissions. In addition to nitrogen additions, weather, soil type, grazing intensity, and other factors influence emissions from grazed lands. Manure deposited on grazed lands also produces CH_4 emissions. Methane emissions from this source are relatively small, less than 5 percent of total grazed land GHG emissions, because of the predominately aerobic conditions that exist on most pastures and ranges.

Grazed lands can be emission sources or net sinks for CO_2. Typically, cropland that has recently been converted to grazed land stores CO_2 from the atmosphere in the form of soil organic carbon. But after sufficient time, soil organic carbon reaches a steady state. Long-term soil carbon levels are sensitive to climate change, and soils that were previously sinks can revert to being sources of CO_2. Woodlands in grazed land can store CO_2 in woody biomass, but this carbon can be returned to the atmosphere if the trees are removed through harvesting or through wildfires and prescribed burns. Conversion of forest lands to grazed lands also contributed CO_2 emissions to the atmosphere with loss of woody biomass. Net CO_2 fluxes depend on the management of woodlands that are designated as grazed lands, levels of deforestation, and whether carbon inputs to the soil—from plant residues and manure—exceed carbon losses from decomposition of soil organic matter. Deforestation is one of the major drivers of anthropogenic greenhouse gas emissions globally, with large losses from tree removal as forest lands are converted to other uses, such as grazed lands, settlements or croplands. Carbon-depleted soils in croplands can act as CO_2 sinks when converted to grazed land, because these areas are typically not plowed after conversion leading to improved soil structure and protection of organic matter in aggregates. Factors such as grazing intensity and weather patterns also influence net CO_2 fluxes in both the trees of woodlands and soils, so a particular parcel of grazed land may be a net source or sink of carbon during any given year.

2.3 U.S. Livestock Populations

Greenhouse gas emissions from livestock are related to population size. Livestock population data are collected annually by USDA's National Agricultural Statistics Service (NASS). Those data are an input into the GHG estimates from livestock in the U.S. GHG Inventory.

Beef and dairy cattle, swine, sheep, goats, poultry, and horses are raised throughout the United States. Detailed livestock population numbers for each State in 2018 are provided in Appendix Table A-1. Appendix Table A-2 shows total national livestock population sizes from 1990 to 2018 by livestock categories. Bison and mules and asses are not presented due to their low contribution to overall emissions estimates. Trends for beef cattle, dairy cattle, and swine are described in more detail below because of their relatively high population numbers and consequently high contributions to GHG emissions:

- Beef: Texas raised by far the most beef cattle, at over 12 million head in 2018 (Appendix Table A-1). Iowa, Kansas, Missouri, Nebraska, Oklahoma, and South Dakota each raised from 4 to 8 million head of beef cattle, while several other States raised ~2 million head. Fewer dairy cattle than beef cattle are raised currently in the United States.
- Dairy: Dairy cattle populations were highest in California and Wisconsin (3.4 million and 2.7 million respectively) (Appendix Table A-1). New York, Idaho, Pennsylvania, and Texas had the next largest populations of dairy cattle, ranging from 1.0 million to 1.3 million head in each State. About half of the remaining States had fewer than 100,000 head of dairy cattle.
- Swine: Iowa was the largest swine producer, with 23 million head in 2018 (Appendix Table A-1). North Carolina housed the second-largest swine population at nearly 9.1 million head. Minnesota, Illinois, and Indiana also have sizeable swine populations.

2.4 Enteric Fermentation

Approximately half of emissions associated with livestock production were from CH_4 produced by enteric fermentation. Cattle were responsible for the majority of enteric CH_4 emissions (97 percent) in 2018 (Table 2-2). Texas (21.6 MMT CO_2 eq.), Nebraska (11.4 MMT CO_2 eq.), and California (11.2 MMT CO_2 eq.) had the largest CH_4 emissions from enteric fermentation for beef cattle and dairy cows in 2018 (Map 2-2, Appendix Table A-3). These emissions were largely tied to the sizable populations of cattle in these States. However, enteric fermentation emissions in Texas and Nebraska were mostly from beef cattle, whereas in California they were derived mostly from dairy cattle (Appendix Table A-3). Central, Northern Plains, and some Great Lakes States also had relatively high CH_4 emissions from enteric fermentation, ranging between 3 and 11 MMT CO_2 eq. per State in 2018 (Appendix Table A-3). Emissions tended to be lower from many States in the Northeast, Southeast, and the Desert Southwest, mainly because cattle populations are low in these States. Non-cattle livestock (i.e., swine, sheep, goats, mules, bison, and horses) generate relatively low contributions to total enteric emissions (Appendix Table A-3). Annual emissions of CH_4 from enteric fermentation fluctuated by approximately 15 MMT CO_2 eq. between 1990 and 2018 (Table 2-4). Emissions peaked in 1995 and again in 2007 (at about 179 MMT CO_2 eq and 174 MMT CO_2 eq., respectively), before dipping to 1990 levels (164 MMT CO_2 eq.) by 2014. In recent years, CH_4 emissions from enteric fermentation have increased.

Map 2-2 Methane Emissions From Enteric Fermentation in 2018
(CH_4 is methane. MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

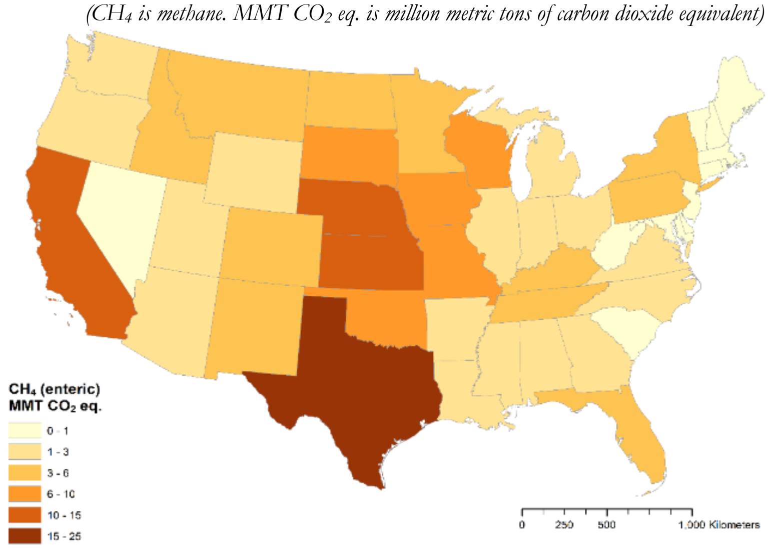


Table 2-4 U.S. Methane Emissions From Enteric Fermentation in 1990, 1995, 2000, 2005, 2010, 2013–2018

Animal Type	*MMT CO_2 eq.*										
	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Beef Cattle	119.1	135.5	126.7	125.2	124.6	118.0	116.5	118.0	123.0	126.3	128.1
Dairy Cattle	39.4	37.5	38.0	37.6	40.7	41.6	42.0	42.6	43.0	43.3	43.6
Sheep	2.3	1.8	1.4	1.2	1.1	1.1	1.0	1.1	1.1	1.1	1.1
Horses	1.0	1.2	1.5	1.7	1.7	1.6	1.5	1.4	1.4	1.3	1.2
Swine	2.0	2.2	2.2	2.3	2.4	2.5	2.4	2.6	2.6	2.7	2.8
Goats	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
American Bison	0.1	0.2	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4
Mules and Asses	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**164.2**	**178.7**	**170.6**	**168.9**	**171.3**	**165.5**	**164.2**	**166.5**	**171.8**	**175.4**	**177.6**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

This increase is driven largely by the recent increase in beef cattle populations (Appendix Table A-2). Overall, by 2018, CH_4 emissions from enteric fermentation increased by 8.2 percent compared to 1990 levels. State-level emissions for 1990, 1995, 2000 and 2005–2013 are presented in Appendix Table A-4.

2.4.1 Methods for Estimating Methane Emissions From Enteric Fermentation

The official U.S. GHG Inventory (EPA 2020) estimates for enteric fermentation (as well as those for managed manure and grazed soils) for years 1990 through 2017 are calculated according to the methodological framework provided by the Intergovernmental Panel on Climate Change (IPCC) for preparing national GHG inventories. The IPCC guidance is organized into a hierarchical, tiered analytical structure, in which higher tiers correspond to more complex and detailed methodologies. The methods detailed below correspond to both Tier 1 and Tier 2 approaches. With the cooperation of EPA, Annex 3.10 from the official U.S. GHG Inventory (EPA 2020) is summarized below. Methane emissions from enteric fermentation were estimated for seven livestock categories: cattle, horses, sheep, swine, goats, American bison, and mules. Emissions from cattle represent the majority of U.S. emissions; consequently, the more detailed IPCC Tier 2 methodology was used to estimate emissions from cattle and the IPCC Tier 1 methodology was used to estimate emissions from the other types of livestock. For 2018, the U.S. GHG Inventory (EPA 2020) used a separate, simplified approach to estimate emissions from cattle. Both methodologies are described below.

2.4.1.1 Estimating Methane Emissions From Cattle for 1990–2017

This section describes the process used to estimate enteric fermentation emissions of CH_4 from cattle on a regional basis. A Cattle Enteric Fermentation Model (CEFM) based on recommendations provided in IPCC (2006, 1997) was developed that uses information on population, energy requirements, digestible energy, and the fraction of energy converted to methane to estimate CH_4 emissions. The emission estimation methodology consists of the following three steps: (1) characterize the cattle population to account for cattle population categories with different emissions profiles; (2) characterize cattle diets to generate information needed to estimate emissions factors; and (3) estimate emissions using these data and the IPCC Tier 2 equations.

Step 1: Characterize U.S. Cattle Population

Calf birth rates, population statistics, feedlot placement information, and slaughter weight data were used to create a transition matrix that models cohorts of individual animal types and their specific emission profiles. This level of detail accounts for the variability in CH_4 emissions associated with each life stage. Given that the time in which cattle can be in a stage can be less than 1 year (e.g., beef calves are weaned at 4 to 6 months or later), the stages are modeled on a per-month basis. The type of cattle use also impacts CH_4 emissions (e.g., beef versus dairy). Consequently, cattle life stages were modeled for several categories of dairy and beef cattle. These categories are listed in Appendix Table A-5. The key variables tracked for each of these cattle population categories includes calving rates, pregnancy and lactation (Appendix Table A-6), average weights and weight gains (Appendix Table A-7), feedlot placements (Appendix Table A-8), death rates, number of animals per category each month, and animal characteristics (i.e., age, gender, etc.) data.

Cattle population data were taken from USDA NASS (National Agricultural Statistics Service) (Appendix Table A-2). USDA NASS publishes monthly, annual, and multi-year livestock population and production estimates. Multi-year reports include revisions to earlier published data. Cattle and calf populations, feedlot placement statistics (e.g., number of animals placed in feedlots by weight class), slaughter numbers, beef calf birth percentages, and lactation data were obtained from NASS QuickStats database (USDA 2019).

Step 2: Characterize U.S. Cattle Diets

Data were collected on diets considered representative of different regions to support development of digestible energy (DE), the percent of gross energy intake digestible to the animal, and CH_4 conversion rate (Y_m), the fraction of gross energy converted to CH_4, values for each of the cattle population categories. For both grazing animals and animals being fed mixed rations, representative regional diets were estimated using information collected from State livestock specialists and from USDA APHIS VS (USDA 2010). The data for each of the diets (e.g., proportions of different feed constituents, such as hay or grains) were used to determine chemical composition for use in estimating DE and Y_m for each animal type. Region- and cattle-type-specific estimates for DE and Y_m were developed for the United States (Appendix Tables A-9 and A-10). Regions in the enteric fermentation model are defined in Appendix Table A-11, A-12. Additional detail on the regional diet characterization is provided in EPA (2020).

Step 3: Estimate Methane Emissions From Cattle

Emissions were estimated in three steps: (a) determine gross energy intake using the IPCC (2006) Tier 2 equations, (b) determine an emissions factor using the gross energy values and other factors, and (c) sum the daily emissions for each animal type. The necessary data values include:

- Body weight (kg)
- Weight gain (kg/day)
- Net energy for activity (Mj/day)
- Standard reference weight (dairy = 1,324 lbs; beef = 1,195 lbs)
- Milk production (kg/day)
- Milk fat (percent of fat in milk = 4)
- Pregnancy (percent of population that is pregnant)
- DE (percent of gross energy intake digestible)
- Y_m (the fraction of gross energy converted to CH_4)
- Population

This process was repeated for each month, and the totals for each subcategory were summed to achieve an emissions estimate for the entire year. The estimates for each of the 12 subcategories of cattle are listed in Appendix Table A-13. The CH_4 emissions for each subcategory were then summed to estimate total emissions from beef cattle and dairy cattle for the entire year. The cattle emissions calculation model estimates emissions on a regional scale. Individual State-level estimates were developed from these regional estimates using the proportion of each cattle population subcategory in the State relative to the population in the region.

2.4.1.2 Estimating Methane Emissions From Cattle for 2018

As noted above, a simplified approach for cattle enteric emissions was used in lieu of the CEFM for 2018. First, 2018 populations for each of the CEFM cattle subcategories were estimated, then these populations were multiplied by the corresponding implied emission factors developed from the CEFM for the 1990–2017 Inventory year (EPA 2019). Dairy cow, beef cow, and bull populations for 2018 were based on data directly from the USDA-NASS *QuickStats* database (USDA 2019). Because the remaining CEFM cattle subcategories (dairy and beef replacements broken out by age, for instance, see Appendix Table A-13) do not correspond exactly to the remaining *QuickStats* cattle categories, 2018 populations for these subcategories were estimated by extrapolating the 2017 populations based on percent changes from 2017 to 2018 in similar *QuickStats* categories, consistent with Volume 1, Chapter 5 of the *2006 IPCC Guidelines* on time-series consistency. Further details regarding this simplified approach may be found in the U.S. GHG Inventory (EPA 2020).

2.4.1.3 Emission Estimates From Other Livestock

Emissions other (non-cattle) livestock used the default Tier 1 emission factor recommended by IPCC (2006). Other livestock population data (sheep, goats, swine, horses, mules, poultry, and American bison) were taken from USDA NASS (2019) or earlier census data. Appendix Table A-2 shows the population data for most livestock that were used for estimating all livestock-related emissions. For each animal category, the USDA publishes monthly, annual, and multi-year livestock population and production estimates. Multi-year reports include revisions to earlier published data. Recent reports were obtained from the USDA Economics and Statistics System, while historical data were downloaded from USDA NASS. National-level emission calculations for other livestock were developed from national population totals. Appendix Table A-14 shows the emission factors used for these other livestock types.

2.4.2 Uncertainty in Estimating Methane Emissions From Enteric Fermentation

The following discussion of uncertainty in the enteric fermentation estimates is from the U.S. GHG Inventory (EPA 2020) and reproduced here.

Uncertainty is estimated using an IPCC-recommended Tier 2 method based on the Monte Carlo Stochastic Simulation technique. Emission factors and animal population data are the primary sources of uncertainty in estimating CH_4 emissions from enteric fermentation. A total of 185 input variables were identified as key input variables for uncertainty analysis (e.g., estimates of births by month, weight gain of animals by age class, and placement of animals into feedlots based on placement statistics and slaughter weight data). The uncertainty associated with these input variables is ±10 percent or lower. However, the uncertainty for many of the emission factors is over ± 20 percent. The overall 95-percent confidence interval around the estimate of 178 MMT CO_2 eq. ranges from 158 to 210 MMT CO_2 eq. (Table 2-1).

2.4.3 Changes Compared to the 4th Edition of the USDA GHG Report

There were several modifications made to the emissions estimates for this edition of the USDA GHG report relative to the previous inventory (USDA 2016). Most of the changes involved revising estimates of animal populations, average weights, and diet assumptions, or refining the models used to calculate emissions. As a result of the changes, annual methane emissions estimates from enteric fermentation decreased on average 0.1 percent for the years 1990 through 2013 as compared to the previous inventory (USDA 2016). The changes ranged from the largest decrease, 0.5 percent (34 kt CH_4), in 2003, to the largest increase, 0.6 percent (38 kt CH_4), in 2013.

2.5 Managed Livestock Manure

Managed livestock manure GHG emissions are composed of CH_4 and N_2O from livestock manure storage, transport, and treatment and CH_4 emissions from the daily spread of livestock manure. Emissions from these sources are discussed below, with estimates disaggregated spatially and by livestock category where possible. Methane was the predominant GHG emitted from managed livestock manure in 2018, accounting for 76 percent of 81 MMT CO_2 eq. total emissions from this source (Table 2-5). The remaining 24 percent of GHG emissions from managed livestock manure was N_2O. Dairy cattle and swine were responsible for 47 percent and 30 percent of total managed manure emissions, respectively (Figure 2-2). Poultry (6 percent) and beef cattle (16 percent) were also important sources in 2018. For beef cattle, N_2O was the predominate form (73 percent) of manure emissions. Over time, emissions from managed manure increased by 59 percent from 1990 to 2018 (Figure 2-3). Most of the increase was from higher CH_4 emissions due to the trend of storing more manure in liquid systems and anaerobic lagoons which facilitate CH_4 production.

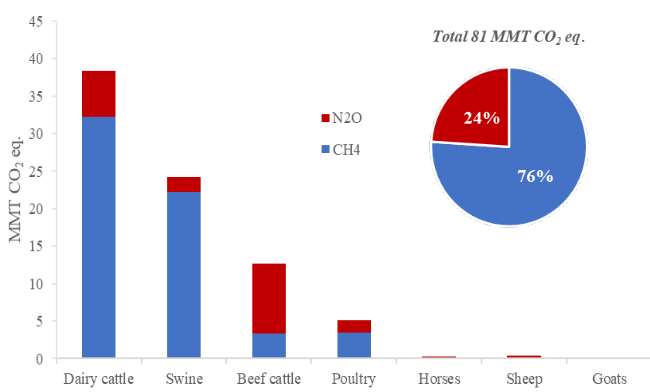


Figure 2-2 Greenhouse Gas Emissions From Managed Livestock Manure by Livestock Type in 2018
(CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide. MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)
Note: Mules and asses and bison are not individually included due to their minimal emissions contributions; however, their emissions are included in the total emissions presented.

While beef cattle contribute the largest overall emissions from all livestock (Table 2-2, Figure 2-1),

Table 2-5 Greenhouse Gas Emissions From Managed Livestock Manure in 1990, 1995, 2000, 2005, 2010, 2013–2018

GHG Type	1990	1995	2000	2005	2010	2015	2016	2017	2018
	MMT CO_2 eq.								
Nitrous Oxide[1]	14.0	15.1	16.4	16.4	17.0	17.5	18.1	18.7	19.4
Methane[2]	37.1	43.3	48.0	51.6	54.9	57.9	59.6	59.9	61.7
Total	**51.1**	**58.4**	**64.4**	**67.9**	**71.9**	**75.4**	**77.7**	**78.5**	**81.1**

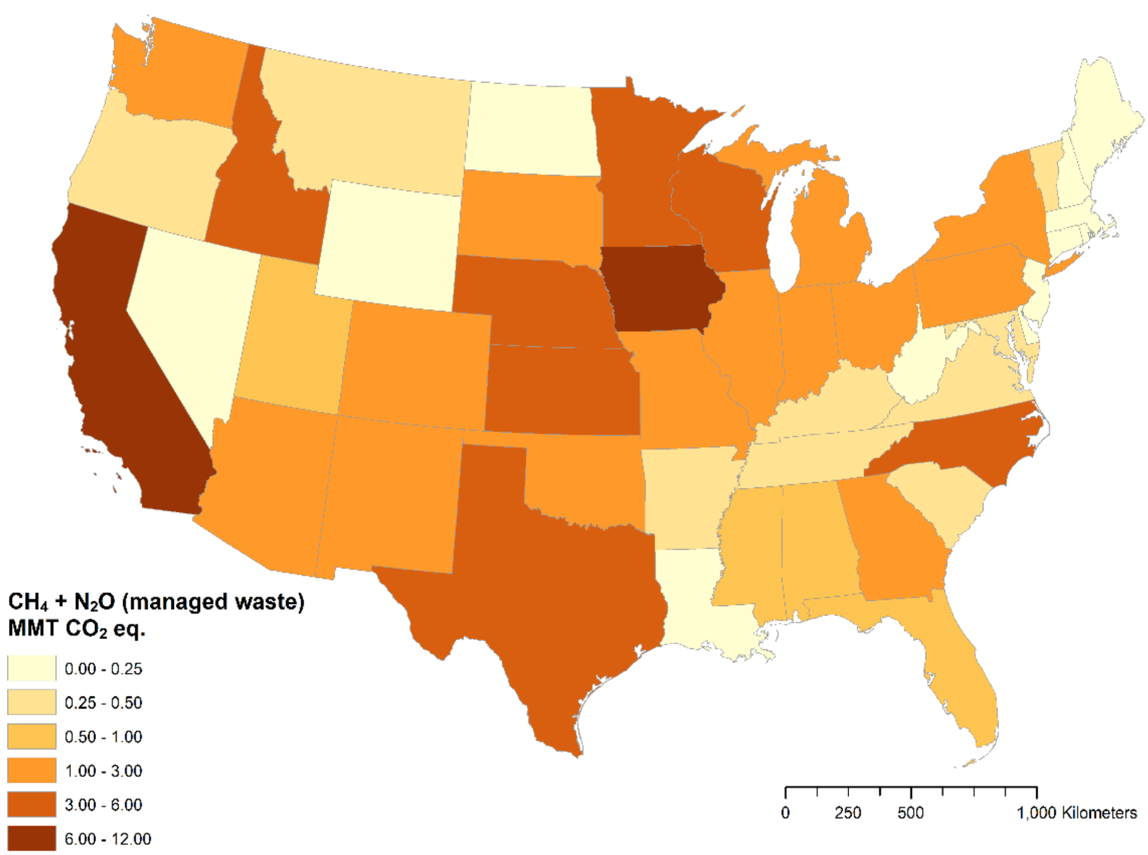
Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1] Does not include emissions from managed manure applied to cropped soils.
[2] Includes CH_4 from managed sources and from grazed grasslands.

emissions from beef-cattle managed manure are relatively small (Figure 2-2) because most manure generated by beef cattle is managed on pasture, range, or paddock. Managed manure emissions from horses, sheep, bison, goats, and mules and asses are small due to the relatively small population of these animals (Appendix Table A-2), and most of the manure is managed on pasture, range, or paddock or managed in dry systems (EPA 2020). State-level GHG emissions from managed livestock manure varied across States in 2018, with a small number of States responsible for the larger contributions to national GHG emissions. California and Iowa had the largest GHG emissions from managed livestock manure, 10.1 and 8.2 MMT CO_2 eq., respectively (Appendix Table A-15). In California, emissions were primarily from dairy cattle. In Iowa, most emissions were from swine (Appendix Table A-16, A-17).

2.5.1 Methods for Estimating Methane and Nitrous Oxide Emissions From Managed Livestock Manure

This section summarizes how CH_4 and N_2O emissions from livestock manure were calculated in the U.S. GHG Inventory (EPA 2020) as well as for this inventory report. Animal population data were used to estimate CH_4 production potential and nitrogen in manure, and these were multiplied by a methane conversion factor (MCF) and direct and indirect N_2O emission factors. MCFs are used to determine the amount of CH_4 emissions that are potentially produced by each unit of livestock manure. MCFs vary

Map 2-3 Greenhouse Gas Emissions From Managed Livestock Manure in 2018
(CH_4 is methane; N_2O is nitrous oxide; MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)



by livestock type, manure storage system, and the manure storage temperature. The IPCC (2006) default direct N_2O emission factor was used, while indirect N_2O emission factors varied by region and manure management system. The EPA provides the USDA with State and national estimates of GHG emissions from managed livestock manure. The estimates of GHG emissions from managed livestock manure were prepared following a methodology developed by EPA, consistent with international guidance, and are described in detail in Annex 3.11 of the U.S. GHG Inventory (EPA 2020).

Data required to calculate CH_4 emissions from livestock manure:

- Animal population data (by animal type and State);
- Typical Animal Mass (TAM) data (by animal type);
- Portion of manure managed in each Manure Management System (WMS), by State and animal type;
- Volatile solids (VS) production rate (by animal type and State or national);
- CH_4 producing potential (B_0) of the volatile solids (by animal type);
- MCF, the extent to which the CH_4 producing potential is realized for each type of WMS (by State and manure management system, including the impacts of any biogas collection efforts).

Nine livestock types are considered for this emissions category: dairy cattle, beef cattle, swine, sheep, goats, poultry, horses, bison, and mules/asses. For swine and dairy cattle, manure management system usage is determined for different farm-size categories using data from the USDA (Ott 2000; USDA 1996a, 1998) and EPA (EPA 2002a, 2002b, ERG 2000, ERG 2018, ERG 2019). For beef cattle and poultry, manure management system usage is not tied to farm size and is based on other sources (ERG 2000, UEP 1999, USDA 2000). For other animal types, manure management system usage is based on previous estimates (EPA 1992).

Appendix Table A-18 presents a summary of the manure characteristics used in the emissions estimates. The method for calculating volatile solids production from beef and dairy cows, heifers, and steers is based on the relationship between animal diet and energy utilization, which is modeled in the enteric fermentation portion of the inventory. Volatile solids content of manure equals the fraction of the diet consumed by cattle that is not digested and thus excreted as fecal material which, when combined with urinary excretions, constitutes manure. Estimations of gross energy intake and digestible energy were used to calculate the indigestible energy per animal unit as gross energy minus digestible energy plus an additional 2 percent of gross energy for urinary energy excretion per animal unit. This was then converted to volatile solids production per animal unit using the typical conversion of dietary gross energy to dry organic matter of 18.45 MJ/kg (IPCC 2006). Appendix Table A-19 shows volatile solid production rates by State and livestock category.

MCFs for liquid-slurry, anaerobic-lagoon, and deep-pit systems were calculated based on the forecast performance of biological systems relative to temperature changes. These calculations account for the following: average monthly ambient temperature, minimum system temperature, the carryover of volatile solids from month to month, and a factor to account for management and design practices that result in loss of volatile solids form lagoon systems. State-level MCFs for liquid-slurry, deep-pit, and anaerobic-lagoon systems are shown in Appendix Table A-20. Appendix Table A-21 has national-scale maximum methane-generation potential (B_0) by animal type, and Appendix Table A-22 has methane conversion factors for dry manure management systems equal to the default IPCC (2006) factors for temperate climates. For each animal type, the base emission factors were weighted to incorporate the distribution of manure

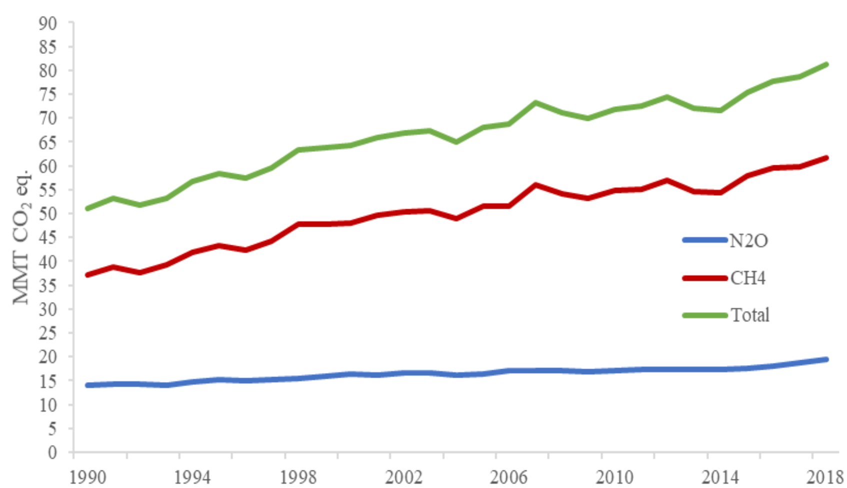


Figure 2-3 Greenhouse Gas Emissions From Managed Livestock Manure, 1990–2018
(CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide. MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

management systems within each State to get a State-level weighted MCF (Appendix Table A-23).

Methane emissions were estimated by multiplying regional or national animal type-specific volatile solid production by the animal type-specific maximum CH_4 production capacity of the manure and the State-specific MCF.

The following inputs were used in the calculation of direct and indirect N_2O emissions:

- Animal population data (by animal type and State);
- TAM data (by animal type);
- Portion of manure managed in each WMS (by State and animal type);
- Total Kjeldahl N excretion rate (Nex);
- Direct N_2O emission factor (EFWMS);
- Indirect N_2O emission factor for volatilization (EFvolitalization);
- Indirect N_2O emission factor for run off and leaching (EFrun off/leach);
- Fraction of N loss from volatilization of ammonia and NOx (Fracgas);
- Fraction of N loss from run off and leaching (Fracrun off/leach)

N_2O emissions were estimated by first determining activity data, including animal population, typical animal mass (TAM), WMS usage, and manure characteristics. N_2O emissions factors for all manure-management systems were set equal to the default IPCC (2006) factors for temperate climates (Appendix A-24). Nex rates for all cattle except for bull and calves were calculated for each State and animal type in the Cattle Enteric Fermentation Model (CEFM), which is described in section 5.1, Enteric Fermentation and in more detail in Annex 3.10, Methodology for Estimating CH4 Emissions From Enteric Fermentation. Nex rates for all other animals were determined using data from USDA's Agricultural Manure Management Field Handbook (USDA 1996b, 2008; ERG 2010a, 2010b) and data from the American Society of Agricultural Engineers, Standard D384.1 (ASAE 2003). All N_2O emissions factors (direct and indirect) were taken from IPCC (IPCC 2006). Country-specific estimates were developed for the fraction of N loss from volatilization (Fracgas) and run off and leaching (Fracrun off/leach). Fracgas values were based on WMS-specific volatilization values as estimated from U.S. EPA's *National Emission Inventory - Ammonia Emissions from Animal Agriculture Operations* (EPA 2005). Fracrun off/leaching values were based on regional cattle run off data from EPA's Office of Water (EPA 2002b; see EPA 2020, Table A-194 in Annex 3.11).

To estimate N_2O emissions, first, the amount of N excreted (kg per year) in manure in each WMS for each animal type, State, and year was calculated. The population (head) for each State and animal was multiplied by TAM (kg animal mass per head) divided by 1,000, the N excretion rate (Nex, in kg N per 1,000 kg animal mass per day), WMS distribution (percent), and the number of days per year.

Direct N_2O emissions were calculated by multiplying the amount of Nex (kg per year) in each WMS by the N_2O direct emission factor for that WMS (EFWMS, in kg N2O-N per kg N, Appendix A-21) and the conversion factor of N_2O-N to N_2O. These emissions were summed over State, animal, and WMS to determine the total direct N_2O emissions (kg of N_2O per year).

Then, indirect N_2O emissions from volatilization (kg N_2O per year) were calculated by multiplying the amount of N excreted (kg per year) in each WMS by the fraction of N lost through volatilization (Fractas) divided by 100, and the emission factor for volatilization (EFvolatilization in kg N_2O per kg N), and the conversion factor of N_2O-N to N_2O. Next,

Table 2-6 Greenhouse Gas Emissions From Grazed Lands in 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
GHG Type	*MMT CO_2 eq.*										
Nitrous Oxide[1]	**95.8**	**95.3**	**87.1**	**97.2**	**101.5**	**103.4**	**103.7**	**104.9**	**99.0**	**98.3**	**99.4**
Direct	86.6	86.0	79.0	88.1	91.9	93.4	94.6	94.3	89.4	88.7	89.7
Indirect Volatilization	3.6	3.5	3.1	3.6	3.5	3.6	3.6	3.5	3.4	3.4	3.4
Indirect Leaching & Runoff	5.6	5.8	5.0	5.5	6.1	6.4	5.5	7.1	6.3	6.2	6.3
Methane[2]	**3.2**	**3.5**	**3.2**	**3.3**	**3.2**	**2.9**	**2.8**	**3.0**	**3.1**	**3.2**	**3.1**
Carbon Dioxide	**2.4**	**(9.1)**	**(42.0)**	**(29.6)**	**(15.3)**	**(14.4)**	**(5.1)**	**(9.6)**	**(15.2)**	**(14.0)**	**(13.4)**
Grazed Lands Remaining Grazed	9.1	8.4	(3.4)	10.7	20.4	16.0	19.7	13.6	9.6	10.9	11.2
Land Converted to Grazed Land	(6.7)	(17.5)	(38.6)	(40.3)	(35.6)	(30.4)	(24.9)	(23.2)	(24.8)	(24.9)	(24.6)
Total	**101.5**	**89.7**	**48.3**	**70.9**	**89.4**	**91.9**	**101.4**	**98.4**	**87.0**	**87.5**	**89.1**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

[1] Does not include emissions from managed manure applied to cropland soils. Emissions (~0.3 MMT CO_2 eq.) from biomass burning are not included.

[2] Grazed lands tend to aerobic and therefore CH_4 emissions are minimal. Emissions (~0.3 MMT CO_2 eq.) from biomass burning are not included.

indirect N_2O emissions from run off and leaching (kg N_2O per year) were calculated by multiplying the amount of N excreted (kg per year) in each WMS by the fraction of N lost through run off and leaching (Fracrun off/leach) divided by 100, and the emission factor for run off and leaching (EFrun off/leach in kg N_2O per kg N), and the conversion factor of N_2O-N to N_2O. The indirect N_2O emissions from volatilization and run off and leaching were summed to determine the total indirect N_2O emissions.

2.5.2 Uncertainty in Estimating Methane and Nitrous Oxide Emissions From Managed Livestock Manure

The following discussion of uncertainty in estimating GHG emissions from livestock manure is modified from information provided in the U.S. GHG Inventory (EPA 2020). The information is reproduced here with cooperation from EPA.

Uncertainty is estimated using an IPCC-recommended Tier 2 method developed by EPA (2003) based on the Monte Carlo Stochastic Simulation technique. A normal probability distribution was assumed for each source data category. The series of equations used were condensed into a single equation for each animal type and State. The results of the uncertainty analysis showed that the manure management CH_4 inventory has a 95-percent confidence interval from 51 to 74 MMT CO_2 eq. around the inventory value of 62 MMT CO_2 eq., and the manure management N_2O inventory has a 95-percent confidence interval from 16 to 24 MMT CO_2 eq. around the inventory value of 19 MMT CO_2 eq. (Table 2-1).

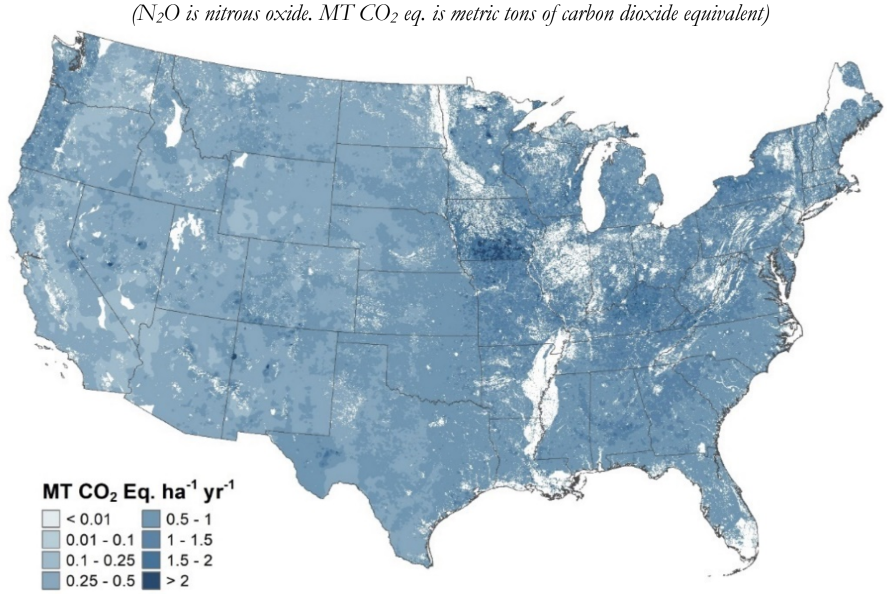
2.5.3 Changes Compared to the 4th Edition of the USDA GHG Report

In addition to updating livestock population data, the total VS and Nex estimates from the CEFM were used in the manure management calculations for cattle in the current inventory. Data from the 2012 and 2017 USDA Census of Agriculture were used to update goat, bison, horse, and mule populations and the WMS distributions for dairy and swine. Temperature data, which are used to estimate MCFs for liquid systems, were updated. Anaerobic digester data were updated using the AgSTAR database. Updated WMS data for dairy and swine were incorporated into the Inventory. In aggregate, annual manure management emissions decreased on average 4.0 percent for the years 1990 through 2013 as compared to the previous inventory (USDA 2016). The changes ranged from the largest decrease 9.0 percent (7.0 MMT CO_2 eq), in 2008, to the largest increase, 0.3 percent (0.2 MMT CO_2 eq), in 1992.

2.6 Grazed Lands

Grazed-land soils emit N_2O due to enhanced nitrogen cycling as well as a relatively small amount of CH_4 emissions from manure deposits Nitrous oxide sources include direct and indirect emissions of N_2O associated with increased nitrogen from synthetic fertilizer, managed manure and biosolid application, forage legumes cultivation, and unmanaged manure from grazing animals. N_2O is also released from decomposition occurring drained organic soils. Grazed lands can be either a source or a sink of CO_2, depending on the level of soil disturbance, soil type, previous land use, fire, and grazing intensity. In general, grazed mineral soils that were previously cropland with annuals will sequester carbon upon conversion to perennial vegetation cover. However, conversion of forest land to grazed land will typically lead to a carbon source with the loss of the tree biomass. In addition, drained organic soils (histosols) used for grazing are typically a CO_2 source because draining enhances decomposition of soil organic matter.

Map 2-4 Nitrous Oxide Emissions From Grazed Soils in 2018[1]
(N_2O is nitrous oxide. MT CO_2 eq. is metric tons of carbon dioxide equivalent)



[1]This map only includes emissions from areas that were in the Tier 3 method. See Appendix Table A-27 for more information about the proportion of land in the Tier 3 method.

Nitrous oxide was the predominant GHG emitted from grazed land soils in 2018, accounting for 90 percent of all emissions from this source (Table 2-6). The remaining 10 percent of GHG emissions from grazed lands are from CO_2, and it is important to note that grazed lands were a sink for CO_2 when including the net uptake of CO_2 in land converted to grazed land in 2018. Nitrous oxide emissions from grazed land totaled 99.4 MMT CO_2 eq. in 2018 (Table 2-6), including direct and indirect sources. Beef cattle are responsible for the highest proportion of direct N_2O emissions from grazed lands because the vast majority of grazed lands in the United States are used for beef production. Texas and Montana had the largest emissions from grazed lands due to the large amounts of rangeland in these States (Map 2-4). Emissions tended to be high in most Great Plains States, again due to large areas of rangeland. In aggregate, emissions from managed grazed land were greater than those of managed manure in 2018 and for most years since 1990, when national emissions from this source were first estimated (Tables 2-5, 2-6). This is due to large numbers of beef cattle on grazed land (about 80 percent of all cattle) compared to feedlots, which are a source of managed manure. In addition to Map 2-4, direct and indirect N_2O emisisons for non-Federal grazed lands are reported in MMT CO_2 eq.'s at the State level in Appendix Table A-25. Similarly, State-level soil C stock changes for non-Federal grasslands are reported in Appendix Table A-26.

2.6.1 Methods for Estimating Nitrous Oxide Emissions From Grazed Lands

Estimates of N_2O emissions from this component were based on DayCent model simulations of non-Federal grazed lands (IPCC Tier 3 approach), estimates of animal manure production and application on to grazed lands (Appendix Table A-27), estimates of synthetic N fertilizer applied to grazed lands, and IPCC (2006) methodology for emissions from Federal grazed lands, grazed organic soils, and biosolids N additions (EPA 2020). Both managed manure applications and unmanaged manure are considered here. Managed manure is defined as manure that was transported and temporarily stored in a management system before soil application. Unmanaged manure remains on soils after being deposited by grazing animals in pastures, rangelands, and paddocks. The livestock included in this component were dairy cattle, beef cattle, swine, sheep, goats, poultry, and horses.

The DayCent ecosystem model simulated non-Federal pastures and rangelands using National Resources Inventory (NRI) survey (USDA-NRCS 2018). The NRI is a statistically based sample of all non-Federal land that includes over 500,000 survey location points in agricultural crop and grazed lands for the conterminous United States and Hawaii (note that not all of these points were simulated using the Tier 3 method). The NRI dataset provides a time series from 1979 through 2015. Each survey location point is associated with an "expansion factor" that allows scaling of N_2O emissions from NRI survey locations to the entire country based on survey statistics. Land-use and some management information (e.g., vegetation type, soil attributes, and irrigation) were originally collected for each NRI point on a 5-year cycle beginning in 1982. However, the NRI program expanded to annual data collection in 1998, and data are currently available through 2015. The last 3 years in the inventory (i.e., 2016–2018) are estimated using a data splicing method with linear regression models and autoregressive moving-average errors because activity data are not available from NRI to apply the DayCent model for these years. This method allows for an approximation of emissions for 2016 to 2018 given trends in the inventory from previous years (See EPA 2020 for more information).

Pastures are defined as grazed lands that are relatively intensively managed and may have been seeded with legumes and/or amended with organic nitrogen (e.g., managed manure) or synthetic fertilizer nitrogen and/or irrigated. Rangelands are typically extensive areas of native grasslands that are not intensively

managed. Grazing intensity on pastures was assumed to be moderate to heavy while intensity on rangelands was assumed to be light to moderate. Key model inputs are daily weather, soil texture class, vegetation mix, animal manure N inputs, and grazing intensity. The model simulates soil water and temperature flows, plant growth and senescence, decomposition of dead plant material and soil organic matter, mineralization of nutrients, and trace gas fluxes. The model also captures the impact of freeze-thaw cycles on nitrous oxide emissions during spring thaw events. Nitrous oxide emissions, nitrate (NO_3) leaching and nitrogen (NO_x, NH_3) volatilization are simulated on a per unit area basis and multiplied by the estimated expansion factor for each NRI survey point. The DayCent simulations are described in more detail in Chapter 3 of this report, EPA (2020, See Annex 3.12) and Del Grosso et al. (2010).

Manure N deposition from grazing animals (i.e., PRP manure) on non-Federal grasslands was an input to the DayCent model (see Annex 3.12 EPA 2020) and included approximately 82 percent of total PRP manure. The remainder of the PRP manure N excretions was assumed to be excreted on Federal grasslands or onto croplands, and the N_2O emissions were estimated using the IPCC (2006) Tier 1 method with default emission factors. Manure nitrogen deposited on grazed lands that was not included in the DayCent simulations as well as biosolid N additions from sewage treatment were multiplied by the default IPCC (2006) emission factor of 0.02 kg N_2O-N/kg N to estimate direct N_2O-nitrogen emissions. Other N inputs to mineral soils are multiplied by a factor of 0.01 kg N_2O-N/kg N used to estimate nitrous oxide emissions from managed soils, including mineral fertilizers, organic amendments, crop residues, and N mineralization from soil carbon losses. Data available at the time that the IPCC (2006) guidelines were developed suggested that the default emission factor should be greater for manure N deposited by grazing animals compared to other N sources. It is noteworthy that more recent observations suggest that this factor should be close to the 0.01 kg N_2O-N/kg N factor (van der Weerden 2011), and so these emissions may be recalculated in the future with a lower emission factor value.

The amounts of PRP manure N applied on non-Federal grasslands at each NRI survey location were based on the proportion of non-Federal grassland area compared to total grassland area according to data from the NRI (USDA-NRCS 2018, relative to the area of Federal grasslands from the U.S. Geological Survey (USGS) National Land Cover Dataset (Forest Inventory and Analysis Data, <http://fia.fs.us/tools-data/data>). Managed manure N amendments were negligible on grasslands with almost all managed manure applied to croplands. Biosolids were assumed to be applied on grazed land instead of cropland because of the heavy metal content and other pollutants in human manure that limit its use as an amendment to croplands. Biosolid application was estimated from data compiled by EPA (1993), NEBRA (2007), and AAPFCO (1995–2014).

For the Tier 3 method, volatilization of applied nitrogen and leaching were calculated using DayCent model in order to estimate indirect nitrous oxide emissions. Nitrogen volatilized, leached, or run off N are all outputs for the grazed lands simulated by DayCent. For Tier 1, IPCC estimates of the portion of volatilized or leached/run off of nitrogen were combined with default emission factor to estimate indirect nitrous oxide emissions. For animal manure not included in the DayCent simulations, 10 percent of animal manure nitrogen was assumed to be volatilized and 30 percent of animal manure nitrogen was assumed to be leached or lost in overland flow as run off. The total volatilized nitrogen was multiplied by the IPCC default emission factor of 0.01 kg N_2O-N/kg N (IPCC 2006). The total nitrogen leached or run off was multiplied by the IPCC (2006) default emission factor of 0.0075 kg N_2O-N/kg N.

Emissions were partitioned by livestock type based on comparing type specific PRP N with total N inputs (Table 2-2). In contrast to the previous editions that partitioned total grassland N_2O among livestock classes, we first isolated the amount of grassland N_2O from PRP and managed manure N additions by assuming that emission are proportional to N inputs (~15 percent of total on average). Then, the N_2O attributable to each livestock class was calculated by multiplying the N_2O obtained in the first step by the portion of total PRP N supplied by that class. This approach is more realistic because the assumption that total N_2O is proportional to animal N manure inputs discounts the other factors that influence emissions such as soil type, SOM levels and weather.

2.6.2 Uncertainty in Nitrous Oxide Emissions From Grazed Lands

Uncertainty associated with model inputs, survey sample and model structure were quantified. Model inputs used to represent N inputs from livestock manure and synthetic fertilizer are not known precisely, and each of these has an associated range of uncertainty represented by statistical imputations of the activity data. Uncertainty is also associated with the NRI sample of survey locations, which is quantified using standard statistical methods for a two-stage sample design. Model structural uncertainty refers to the errors inherent in the model. That is, the model does not yield perfect results even if model inputs were precisely known. To address model structural uncertainty, DayCent-simulated N_2O emissions were compared with measured emissions from 13 grassland experiments with 36 treatments. Uncertainties were combined using a Monte Carlo simulation approach. IPCC (2006) methodology was used to estimate uncertainties for Federal grazed lands not included in the DayCent simulations. Uncertainty from the DayCent-simulated grazed land was combined with uncertainty for remaining grazed lands calculated using IPCC (2006) methodology based on a simple error propagation. There were also additional uncertainties associated with the data splicing method that was used to estimate CO_2 fluxes from 2016 to 2018. The calculated 95-percent confidence interval around the estimate of 99 MMT CO_2 eq. for grazed land soil N_2O emissions was 60 to 142 MMT CO_2 eq. (Table 2-1). Uncertainty calculations are described in detail in Chapter 3 of this report.

2.6.3 Methodology to Estimate Methane Emissions From Grazed Lands

Methane emissions were estimated by multiplying regional or national animal-type-specific volatile solid production by the animal-type-specific maximum CH_4 production capacity of the manure and the national MCF for manure deposited on grazed lands. As noted previously, these emissions are very small because of predominately aerobic conditions in deposited manure.

2.6.4 Changes Compared to the 4th Edition of the USDA GHG Report

There were several changes compared to the previous inventory. The most important change was development of detailed time series of management activity data by combining information in an imputation analysis from USDA-NRCS Conservation Effects Assessment Project survey, USDA-ERS Agricultural Resource Management Surveys data, Conservation Tillage Information Center surveys and USDA Census of Agriculture data. This improvement had a larger impact on cropland estimates, as discussed in Chapter 3 of this report, but also influenced the estimation of emissions from grazed lands, such as constraints on total fertilizer and manure additions to soils. This inventory has also been improved with estimation of biomass and dead organic matter carbon stock changes associated with woodlands and deforestation, i.e., conversion of forest land to grazed land. Other improvements include refinements to DayCent model structure and parameterization, particularly the simulation of freeze-thaw impacts on nitrous oxide emissions and modeling soil organic carbon to a 30 cm depth instead of 20 cm, in addition to using data splicing methods to estimate emissions in years with no activity data at the end of the time series. In aggregate, these changes resulted in an approximate 10-percent increase in N_2O emissions from grazed lands on average for 1990 to 2013.

2.6.5 Methods for Estimating Carbon Dioxide Fluxes for Grazed Lands

As with N_2O emissions, carbon dioxide (CO_2) fluxes for non-Federal grasslands were estimated using results from the DayCent ecosystem model and IPCC (2006) methodology. See section 2.6.1 for details on model simulations. DayCent has been parameterized to simulate continuous grazed grasslands and croplands converted to grazed grassland, but not other land uses converted to grazed grassland. IPCC (2006) methodology was used to estimate CO_2 fluxes for land converted from non-agricultural uses to grazed land. Also, DayCent has not been well tested with organic soils, so IPCC (2006) methodology was used for grazed lands with organic soils. Biomass and dead organic matter carbon were estimated using a Tier 2 method for woodlands and deforestation with forest land converted to grazed land. This is the same method that is used to estimate changes in the forest land stock changes based on data from the USDA Forest Service, Forest Inventory and Analysis (FIA) program (USDA Forest Service 2019).

Both DayCent and IPCC (2006) methodologies rely on land use classifications and land use histories. The National Resources Inventory (NRI; USDA-NRCS 2018) was used to identify grazed lands and land use conversions. Grazed lands include pasture and rangeland where the primary land use is livestock grazing. According to NRI data, ~20 million ha of grazed land (out of a total ~337 million ha reported in 2015) were converted to grazed land between 1996 and 2015. An example of land converted to grazed land is land that was in cropland historically but then converted to pasture. Carbon dioxide fluxes for grazed lands were calculated using estimates of changes in soil organic carbon stocks, in addition to dead organic matter and woody biomass carbon stocks for woodlands and areas converted from forest land to grazed land.

DayCent estimates carbon-stock changes by determining carbon inputs from plant production and manure, and decomposition of the soil organic matter. The DayCent model requires input data on weather and soil texture, and these simulations also included estimates of managed manure additions to grasslands. For details on sources of the input data required to run DayCent and how the simulations were conducted, see Chapter 3 of this report and Chapter 7 and Annex 3.12 of the U.S. GHG Inventory (EPA 2020).

The IPCC method (2006) was applied at a Tier 2 level for mineral soils that were not included in the Tier 3 method with DayCent and all organic soils. This method used U.S.-specific stock change factors based on field data compiled from studies in North America.

2.6.6 Uncertainty in Carbon Dioxide Fluxes for Grazed Lands

Uncertainty for the estimates of CO_2 fluxes from mineral soil that are grazed land remaining grazed land and cropland converted to grazed land from the DayCent model simulations used a Monte Carlo approach, which addresses uncertainties in model inputs, uncertainty in model structure, and uncertainties in the sample from the NRI based on the survey design (See section2.6.2 for more information). To assess structural uncertainty, DayCent simulated soil C-stock changes were compared with measured values from over 45 grassland experiments in North America. Uncertainty for estimates from other land uses converted to grazing and all organic soils were derived using a Monte Carlo approach that addressed uncertainties in carbon-stock change factors and in land use and management data. There were also additional uncertainties associated with the data splicing method that was used to estimate CO_2 fluxes from 2016 to 2018. Uncertainties for the DayCent model output and Tier 1 analysis were combined using simple error propagation. The results yielded an uncertainty of (134) to 157 around the estimate of 11 MMT CO_2 eq. in 2018 for land remaining grazed land and (59) to 9 around the estimate of (9) MMT CO_2 eq. for land converted to grazed land in 2018, where parentheses indicate a net sequestration of CO_2 (Table 2-1). Uncertainty calculations are described in detail in Chapter 3 of this report.

2.6.7 Changes Compared to the 4th Edition of the USDA GHG Report

As with N_2O, the major change compared to the previous inventory was developing a more detailed time series of management data (see section 2.6.4 for details). The changes resulted in an increase in estimated C sink of approximately 21.1 MMT CO_2 eq. on average (110-percent increase), compared to the previous inventory.

2.7 Planned Improvements

There are a few areas where changes could be made to improve upon the existing inventory as well as the annual inventory complied by the EPA. Regarding enteric CH_4 emissions, changes involve updating and refining input values such as cattle births, diet data, animal weight gains, emissions factors, and updating the uncertainty methodology. For managed manure emissions, the uncertainty analysis will be updated to address updates to methodologies for both methane and nitrous oxide emissions estimates. Investigation into updated WMS data and U.S. specific B_0 data will be continued. For grazing emission from soils, major improvements include refining the DayCent model, particularly the impact of nitrification inhibitors and slow-release fertilizers (e.g., polymer-coated fertilizers) on N_2O emissions, as well as new updates to the activity data from the NRI survey and other management data products. Future inventories will attempt to quantify mitigation potentials from all sources related to livestock production.

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2.9 Appendix A

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Appendix Table A-1 Population of Animals by State in 2018

	Beef Cattle	Dairy Cattle	Swine	Sheep	Goat	Horse	Poultry
State				*Head*			
Alabama	1,247,079	14,678	53,000	12,917	51,029	46,925	221,987,695
Alaska	11,220	557	1,900	12,917	845	1,433	1,884,137
Arizona	778,351	416,019	170,000	125,000	58,934	75,281	1,884,137
Arkansas	1,685,511	12,151	130,000	12,917	35,688	42,164	233,391,455
California	2,055,820	3,436,099	101,000	570,000	131,988	91,034	33,190,303
Colorado	3,232,019	336,504	767,500	445,000	51,691	95,002	6,623,604
Connecticut	11,392	38,478	3,700	8,167	5,750	10,186	1,884,137
Delaware	5,964	9,824	6,500	12,917	1,445	3,782	49,811,410
Florida	1,572,870	220,948	13,000	12,917	62,980	84,559	21,189,513
Georgia	925,230	156,534	67,000	12,917	69,877	47,911	278,590,876
Hawaii	134,090	4,659	9,000	12,917	16,871	4,435	1,884,137
Idaho	1,463,626	1,225,140	32,000	235,000	30,339	45,875	1,884,137
Illinois	1,151,106	193,865	5,350,000	55,000	37,179	39,596	17,587,240
Indiana	586,436	362,095	4,100,000	57,000	41,690	74,090	61,463,303
Iowa	4,006,125	463,037	23,025,000	165,000	86,466	48,538	86,969,303
Kansas	7,214,253	328,890	2,045,000	67,000	50,267	49,115	1,884,137
Kentucky	1,931,021	126,987	285,000	58,000	58,963	115,131	64,025,058
Louisiana	804,344	22,293	6,000	12,917	18,917	40,465	13,541,240
Maine	25,424	60,755	4,400	8,167	5,782	7,861	1,884,137
Maryland	98,656	100,708	19,000	12,917	14,451	27,430	57,020,785
Massachusetts	14,177	24,545	8,000	8,167	7,439	13,433	487,604
Michigan	499,737	817,993	1,200,000	80,000	29,659	59,440	31,819,303
Minnesota	1,456,705	996,875	8,625,000	130,000	36,830	42,978	38,930,455
Mississippi	876,649	19,733	575,000	12,917	31,866	36,837	145,962,240
Missouri	4,012,419	174,650	3,562,500	100,000	71,472	79,189	77,960,242
Montana	2,994,094	30,362	192,000	225,000	15,110	74,934	1,539,604
Nebraska	8,130,247	116,486	3,475,000	80,000	29,708	45,450	20,919,240
Nevada	421,435	56,736	6,000	61,000	11,723	12,461	1,884,137
New Hampshire	10,344	26,586	3,500	8,167	4,099	6,597	1,884,137
New Jersey	15,567	13,616	8,500	12,917	11,360	22,517	1,884,137
New Mexico	942,749	605,430	1,300	96,000	35,795	41,895	1,884,137
New York	294,100	1,300,806	46,000	85,000	29,300	64,287	17,362,240
North Carolina	686,590	90,630	9,050,000	27,000	55,987	48,161	191,353,697
North Dakota	1,977,540	33,407	145,000	70,000	7,009	26,253	1,884,137
Ohio	846,140	519,539	2,600,000	119,000	61,223	93,792	65,451,515
Oklahoma	4,736,946	73,392	2,200,000	54,000	98,293	118,861	40,561,422
Oregon	1,188,512	254,133	9,000	165,000	47,808	62,743	13,731,240
Pennsylvania	577,738	1,115,951	1,280,000	96,000	53,101	82,032	72,816,152
Rhode Island	2,944	1,721	1,700	8,167	964	1,913	1,884,137
South Carolina	309,817	29,875	200,000	12,917	41,125	40,138	49,261,967
South Dakota	4,049,689	221,857	1,700,000	250,000	18,133	49,436	4,858,667
Tennessee	1,691,668	97,599	220,000	46,000	99,113	85,005	35,363,967
Texas	12,632,861	1,007,396	1,125,000	750,000	829,684	317,642	148,750,785
Utah	703,786	195,356	587,500	275,000	20,365	51,727	6,155,604
Vermont	34,808	252,705	3,700	8,167	9,643	7,894	501,604
Virginia	1,247,551	170,663	345,000	75,000	48,568	61,338	60,492,091
Washington	787,919	539,336	17,000	45,000	29,858	50,310	18,838,240
West Virginia	392,257	16,201	4,000	35,000	24,191	22,873	18,110,788
Wisconsin	1,076,566	2,662,525	325,000	75,000	108,303	69,159	19,267,058
Wyoming	1,509,200	12,151	88,000	345,000	15,180	52,369	1,884,137
Total	**83,061,291**	**19,008,478**	**73,792,700**	**5,265,000**	**2,714,060**	**2,692,477**	**2,252,265,424**

Note: Bison and mules and assess populations are not presented here due to their minor contribution to emissions estimates.
Source: EPA 2020

Appendix Table A-2 U.S. Livestock Population, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Animal Type						*1 million head*					
Dairy cattle[1]	**20**	**19**	**18**	**18**	**18**	**19**	**19**	**19**	**19**	**19**	**19**
Dairy Cows	10	9	9	9	9	9	9	9	9	9	9
Dairy Heifers	4	4	4	4	5	5	5	5	5	5	5
Dairy Calves	5	5	5	5	5	5	5	5	5	5	5
Swine	**54**	**59**	**59**	**61**	**65**	**65**	**64**	**68**	**70**	**72**	**74**
Market <50 lbs.	18	20	20	20	19	19	19	20	21	21	21
Market 50–119 lbs.	12	13	13	14	17	17	17	18	18	19	19
Market 120–179 lbs.	9	11	11	11	12	13	12	13	14	14	14
Market >180 lbs.	8	9	9	10	11	11	11	12	12	12	12
Breeding	7	7	6	6	6	6	6	6	6	6	6
Beef cattle	**82**	**90**	**85**	**82**	**80**	**76**	**75**	**76**	**79**	**82**	**83**
Feedlot Steers	6	7	8	8	9	9	9	9	9	10	10
Feedlot Heifers	3	4	5	5	5	5	5	4	4	5	5
Bulls NOF[2]	2	2	2	2	2	2	2	2	2	2	2
Beef Calves NOF	17	18	17	17	16	15	15	15	16	16	16
Heifers NOF	10	12	10	10	9	9	9	9	10	10	10
Steers NOF	10	12	9	8	8	7	7	7	8	8	8
Cows NOF	32	35	34	33	31	30	29	29	30	31	31
Sheep	**11**	**9**	**7**	**6**	**6**	**5**	**5**	**5**	**5**	**5**	**5**
Feedlot Sheep	1	2	3	3	3	3	3	3	3	3	3
Sheep NOF	10	7	4	3	3	3	3	3	3	3	3
Goats	**3**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Poultry	**1,537**	**1,827**	**2,033**	**2,150**	**2,104**	**2,107**	**2,116**	**2,134**	**2,173**	**2,214**	**2,252**
Hens >1 yr.	273	299	334	348	342	361	371	352	377	388	397
Pullets	73	81	95	97	106	107	106	118	112	117	124
Chickens	7	8	8	8	7	7	6	7	7	7	7
Broilers	1,066	1,332	1,506	1,613	1,568	1,552	1,554	1,580	1,596	1,621	1,643
Turkeys	118	107	90	84	81	80	79	78	81	82	82
Horses	**2**	**3**	**3**	**4**	**4**	**3**	**3**	**3**	**3**	**3**	**3**

Note: Totals may not sum due to independent rounding. Bison and mules and assess populations are not presented here due to their minor contribution to emissions estimates.
Source: EPA 2020
[1]Dairy cattle does not include dairy calves.
[2](NOF) Not on feed.

Appendix Table A-3 State-Level Methane Emissions From Enteric Fermentation by Livestock Category in 2018

	Beef cattle	Dairy cattle	Swine	Horses	***Total****
State		*MMT CO_2 eq.*			
Alabama	2.10	0.03	0.00	0.02	2.17
Alaska	0.02	0.00	0.00	0.00	0.03
Arizona	1.14	0.98	0.01	0.03	2.19
Arkansas	2.83	0.02	0.00	0.02	2.89
California	3.25	7.91	0.00	0.04	11.34
Colorado	4.82	0.76	0.03	0.04	5.77
Connecticut	0.02	0.09	0.00	0.00	0.12
Delaware	0.01	0.02	0.00	0.00	0.04
Florida	2.66	0.58	0.00	0.04	3.29
Georgia	1.56	0.42	0.00	0.02	2.02
Hawaii	0.24	0.01	0.00	0.00	0.26
Idaho	2.35	2.89	0.00	0.02	5.36
Illinois	1.67	0.40	0.20	0.02	2.31
Indiana	0.87	0.80	0.15	0.03	1.87
Iowa	5.54	1.00	0.86	0.02	7.48
Kansas	9.81	0.70	0.08	0.02	10.64

	Beef cattle	Dairy cattle	Swine	Horses	*Total**
State	*MMT CO_2 eq.*				
Kentucky	3.22	0.30	0.01	0.05	3.62
Louisiana	1.36	0.04	0.00	0.02	1.43
Maine	0.04	0.14	0.00	0.00	0.19
Maryland	0.16	0.23	0.00	0.01	0.40
Massachusetts	0.02	0.05	0.00	0.01	0.09
Michigan	0.70	1.95	0.05	0.03	2.74
Minnesota	2.06	2.06	0.32	0.02	4.50
Mississippi	1.48	0.04	0.02	0.02	1.57
Missouri	6.48	0.31	0.13	0.04	6.99
Montana	5.34	0.06	0.01	0.03	5.53
Nebraska	11.15	0.26	0.13	0.02	11.65
Nevada	0.75	0.13	0.00	0.01	0.90
New Hampshire	0.02	0.06	0.00	0.00	0.09
New Jersey	0.03	0.03	0.00	0.01	0.07
New Mexico	1.68	1.49	0.00	0.02	3.22
New York	0.48	3.19	0.00	0.03	3.73
North Carolina	1.16	0.24	0.34	0.02	1.77
North Dakota	3.19	0.07	0.01	0.01	3.32
Ohio	1.26	1.10	0.10	0.04	2.54
Oklahoma	7.65	0.16	0.08	0.05	7.98
Oregon	2.05	0.55	0.00	0.03	2.67
Pennsylvania	0.89	2.55	0.05	0.04	3.56
Rhode Island	0.00	0.00	0.00	0.00	0.01
South Carolina	0.53	0.07	0.01	0.02	0.63
South Dakota	6.26	0.49	0.06	0.02	6.95
Tennessee	2.83	0.22	0.01	0.04	3.13
Texas	19.04	2.50	0.04	0.14	22.02
Utah	1.24	0.45	0.02	0.02	1.79
Vermont	0.06	0.60	0.00	0.00	0.66
Virginia	2.07	0.44	0.01	0.03	2.57
Washington	1.21	1.28	0.00	0.02	2.53
West Virginia	0.66	0.03	0.00	0.01	0.71
Wisconsin	1.54	5.84	0.01	0.03	7.47
Wyoming	2.63	0.03	0.00	0.02	2.77
Total	128.13	43.60	2.77	1.21	177.57

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
Source: EPA 2020
*State totals include all livestock categories

Appendix Table A-4 State-Level Methane Emissions From Enteric Fermentation in 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018[1]
State	*MMT CO_2 eq.*										
Alabama	2.53	2.82	2.37	2.16	2.05	2.10	2.07	1.98	2.04	2.11	2.13
Alaska	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Arizona	1.55	1.62	1.60	1.85	1.94	1.98	1.99	1.94	1.99	2.09	2.12
Arkansas	2.82	3.17	2.91	3.01	2.98	2.59	2.66	2.65	2.79	2.81	2.85
California	8.69	9.04	9.90	10.66	11.12	11.15	11.26	10.96	11.02	11.05	11.19
Colorado	4.34	4.93	5.02	4.21	4.79	4.91	4.91	5.00	5.28	5.51	5.58
Connecticut	0.17	0.16	0.15	0.12	0.10	0.11	0.10	0.11	0.11	0.11	0.11
Delaware	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
Florida	3.58	3.87	3.43	3.26	3.25	3.31	3.18	3.21	3.19	3.20	3.24
Georgia	2.25	2.49	2.18	2.10	1.88	1.81	1.86	1.84	1.95	1.95	1.98
Hawaii	0.32	0.30	0.29	0.28	0.26	0.23	0.23	0.23	0.24	0.25	0.25
Idaho	2.87	3.33	3.72	4.14	4.56	4.99	4.76	4.91	5.16	5.19	5.25

Illinois	2.71	2.66	2.36	2.15	1.97	1.88	1.91	1.90	1.99	2.05	2.07
Indiana	1.95	1.87	1.54	1.49	1.56	1.45	1.50	1.57	1.61	1.65	1.67
Iowa	6.49	6.41	5.91	5.71	6.23	6.13	6.07	6.18	6.42	6.46	6.54
Kansas	7.79	9.38	9.37	9.60	9.36	8.92	9.08	9.33	9.93	10.36	10.50
Kentucky	3.92	4.31	3.63	3.80	3.70	3.56	3.42	3.39	3.52	3.48	3.52
Louisiana	1.85	1.74	1.62	1.57	1.53	1.40	1.39	1.42	1.37	1.38	1.40
Maine	0.23	0.22	0.21	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18
Maryland	0.61	0.61	0.51	0.44	0.40	0.38	0.37	0.38	0.39	0.38	0.39
Massachusetts	0.16	0.14	0.12	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Michigan	2.08	2.10	1.86	1.91	2.20	2.31	2.37	2.44	2.53	2.62	2.65
Minnesota	4.35	4.39	4.09	3.75	3.89	3.92	3.83	3.89	4.06	4.08	4.13
Mississippi	2.12	2.18	1.81	1.79	1.62	1.55	1.54	1.51	1.60	1.50	1.52
Missouri	6.63	7.34	6.76	6.84	6.35	5.61	5.89	6.08	6.28	6.69	6.78
Montana	4.00	4.98	4.87	4.47	5.13	5.24	5.24	5.26	5.35	5.32	5.39
Nebraska	8.88	9.83	10.52	10.21	10.41	10.46	10.43	10.50	11.06	11.26	11.40
Nevada	0.90	0.92	0.92	0.91	0.90	0.88	0.89	0.83	0.85	0.87	0.88
New Hampshire	0.10	0.10	0.10	0.09	0.08	0.08	0.07	0.07	0.08	0.08	0.08
New Jersey	0.14	0.13	0.10	0.08	0.07	0.06	0.05	0.06	0.06	0.06	0.06
New Mexico	2.37	2.82	3.05	3.10	3.29	3.04	2.90	2.89	2.96	3.13	3.17
New York	3.44	3.26	3.34	3.16	3.30	3.36	3.49	3.51	3.61	3.64	3.69
North Carolina	1.51	1.81	1.59	1.47	1.34	1.35	1.33	1.35	1.34	1.38	1.39
North Dakota	2.83	3.44	3.22	3.09	2.99	3.09	3.04	2.91	3.04	3.21	3.25
Ohio	2.55	2.45	2.14	2.27	2.33	2.27	2.29	2.26	2.29	2.34	2.37
Oklahoma	7.24	8.07	7.37	7.67	7.98	6.34	6.57	6.94	7.29	7.70	7.80
Oregon	2.46	2.81	2.65	2.73	2.47	2.46	2.45	2.50	2.53	2.56	2.60
Pennsylvania	3.64	3.46	3.40	3.19	3.28	3.32	3.35	3.27	3.35	3.41	3.46
Rhode Island	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
South Carolina	0.91	0.87	0.78	0.74	0.65	0.57	0.58	0.58	0.60	0.59	0.59
South Dakota	5.35	6.43	6.26	6.24	6.35	6.42	6.27	6.37	6.71	6.66	6.74
Tennessee	3.61	4.01	3.42	3.52	3.31	2.98	2.85	2.87	2.98	3.02	3.05
Texas	20.76	24.66	22.40	22.33	22.48	19.67	18.79	19.88	20.42	21.26	21.53
Utah	1.44	1.63	1.64	1.60	1.58	1.66	1.65	1.61	1.67	1.67	1.69
Vermont	0.71	0.68	0.70	0.64	0.62	0.65	0.64	0.64	0.65	0.65	0.66
Virginia	2.73	2.82	2.58	2.67	2.56	2.64	2.48	2.45	2.44	2.47	2.50
Washington	2.57	2.60	2.51	2.22	2.23	2.41	2.38	2.42	2.48	2.46	2.50
West Virginia	0.76	0.82	0.68	0.67	0.65	0.68	0.65	0.62	0.67	0.68	0.69
Wisconsin	7.42	6.61	6.36	6.16	6.70	6.89	6.87	7.11	7.25	7.31	7.40
Wyoming	2.05	2.56	2.68	2.30	2.50	2.50	2.50	2.55	2.57	2.62	2.65
Total	**158.44**	**172.93**	**164.72**	**162.76**	**165.29**	**159.66**	**158.47**	**160.69**	**166.02**	**169.57**	**171.74**

Note: State-level emissions do not include data for non-cattle. MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

[1] Because a simplified approach was used for the 1990–2018 Inventory to estimate Enteric Fermentation emissions, 2018 State values are based on each State's percent of total emissions in 2017.

Source: EPA 2020

Appendix Table A-5 Cattle Population Categories Used for Estimating Methane Emissions

Dairy Cattle	*Beef Cattle*
Calves (4–6 mo)	Calves (4–6 mo)
Heifer Replacements	Heifer Replacements
Cows	Heifer and Steer Stockers
	Animals in Feedlots (Heifers and Steers)
	Cows
	Bulls[1]

Source: EPA 2020

[1] Bulls (beef and dairy) are accounted for in a single category.

Appendix Table A-6 Dairy Lactation by Region[1], 1990, 1995, 2000, 2005, 2010, 2013–2018

	California	West	Northern Great Plains	Southcentral	Northeast	Midwest	Southeast
Year				*(lbs * year)/cow*			
1990	18,456	17,275	13,438	13,405	14,564	14,225	12,868
1995	19,573	18,729	14,807	14,291	16,264	15,688	14,329
2000	21,130	20,786	17,154	15,341	17,490	17,438	15,192
2005	21,404	21,696	19,484	18,233	18,448	18,833	16,050
2010	23,025	23,065	21,281	20,264	19,955	20,324	17,330
2013	23,178	23,492	22,335	21,094	20,677	21,276	17,982
2014	23,786	23,978	22,800	21,513	21,007	21,546	18,859
2015	23,028	23,759	23,302	21,622	21,326	22,195	19,468
2016	22,968	24,050	23,585	22,053	21,906	22,837	19,453
2017	22,755	24,022	23,871	22,930	22,141	23,132	19,785
2018	23,301	24,244	23,914	23,220	22,026	23,323	19,520

Source: EPA 2020

[1] Beef lactation data developed using methodology described in EPA 2020.

Appendix Table A-7 Typical Livestock Weights for 2018

Cattle Type	*lbs*
Calves	269
Dairy Cows	1,499
Dairy Replacements	899
Beef Cows	1,220
Bulls	1,830
Beef Replacements	819
Steer Stockers	691
Heifer Stockers	651
Steer Feedlot	923
Heifer Feedlot	845

Source: Feedstuffs (1998), Western Dairyman (1998), Enns (2008), Johnson (2010), NRC (1999), Holstein Association 2010, USDA (2013), EPA 2020.

Appendix Table A-8 U.S. Feedlot Placements for 2018[1]

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	*Total*
Weight Placed						*Number of animals placed, 1,000 head*							
< 600 lbs.	380	315	350	348	400	375	360	360	405	675	610	470	**5,048**
600–700 lbs.	445	330	295	255	315	315	235	285	340	590	545	410	**4,360**
700–800 lbs.	585	490	630	490	529	430	385	418	490	510	455	445	**5,857**
> 800 lbs.	571	559	842	755	875	650	635	865	915	618	489	474	**8,248**
Total	**1,981**	**1,694**	**2,117**	**1,848**	**2,119**	**1,770**	**1,615**	**1,928**	**2,150**	**2,393**	**2,099**	**1,799**	**23,513**

Source: USDA (2002f, 2001f, 2000f, 1999a, 1995a), EPA 2020.

Note: Totals may not sum due to independent rounding.

[1] Because a simplified approach was used for the 1990–2018 Inventory to estimate Enteric Fermentation emissions, 2018 values were set equal to 2017 data.

Appendix Table A-9 Regional Estimates of Digestible Energy and Methane Conversion Rates for Foraging Animals 2007–2018

Animal Type	Data	West	Central	Northeast	Southeast
Beef Repl. Heif.	DE [1]	61.9	65.6	64.5	64.6
	Ym [2]	6.5%	6.5%	6.5%	6.5%
Steer Stockers	DE	61.9	65.6	64.5	64.6
	Ym	6.5%	6.5%	6.5%	6.5%
Heifer Stockers	DE	61.9	65.6	64.5	64.6
	Ym	6.5%	6.5%	6.5%	6.5%
Beef Cows	DE	59.9	63.6	62.5	62.6
	Ym	6.5%	6.5%	6.5%	6.5%
Beef Calves (4–6 mo)	DE	61.9	65.6	64.5	64.6
	Ym	6.5%	6.5%	6.5%	6.5%
Bulls	DE	59.9	63.6	62.5	62.6
	Ym	6.5%	6.5%	6.5%	6.5%

Source: EPA 2020

[1] (DE) Digestible energy; in units of percent gross energy (GE) in MJ/Day.

[2] (Y_m) Methane conversion rate is the fraction of gross energy (GE) in feed converted to methane.

Appendix Table A-10 Regional Estimates of Digestible Energy and Methane Conversion Rates for Dairy and Feedlot Cattle for 2018

Animal Type	Data	California	West	Northern Great Plains	Southcentral	Northeast	Midwest	Southeast
Dairy Repl. Heif.	DE[1]	63.7	63.7	63.7	63.7	63.7	63.7	63.7
	Ym[2]	6.0%	6.0%	5.7%	6.5%	6.4%	5.7%	7.0%
Steer Feedlot	DE	82.5	82.5	82.5	82.5	82.5	82.5	82.5
	Ym	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Heifer Feedlot	DE	82.5	82.5	82.5	82.5	82.5	82.5	82.5
	Ym	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Dairy Cows	DE	66.7	66.7	66.7	66.7	66.7	66.7	66.7
	Ym	5.9%	5.9%	5.6%	6.4%	6.3%	5.6%	6.9%
Dairy Calves (4–6 mo)	DE	63.7	63.7	63.7	63.7	63.7	63.7	63.7
	Ym	7.8% (6 mo), 8.03% (5 mo), 8.27% (4 mo) - all regions						

Source: EPA 2020

[1] (DE) Digestible energy; in units of percent gross energy (GE) in megajoules (MJ) per day.

[2] (Y_m) Methane conversion rate is the fraction of gross energy (GE) in feed converted to methane.

Appendix Table A-11 Definition of Regions for Characterizing the Diets of Dairy Cattle (All Years) and Foraging Cattle 1990–2006

Region & State(s)

California	West	Northern Great Plains	Midwest	Northeast	South Central	Southeast
California	Alaska	Colorado	Illinois	Connecticut	Arkansas	Alabama
	Arizona	Kansas	Indiana	Delaware	Louisiana	Florida
	Hawaii	Montana	Iowa	Maine	Oklahoma	Georgia
	Idaho	Nebraska	Michigan	Maryland	Texas	Kentucky
	Nevada	North Dakota	Minnesota	Massachusetts		Mississippi
	New Mexico	South Dakota	Missouri	New Hampshire		North Carolina
	Oregon	Wyoming	Ohio	New Jersey		South Carolina
	Utah		Wisconsin	New York		Tennessee
	Washington			Pennsylvania		Virginia
				Rhode Island		
				Vermont		
				West Virginia		

Source: EPA 2020

Appendix Table A-12 Definition of Regions for Characterizing the Diets of Foraging Cattle From 2007–2018

Region & State(s)			
West	**Central**	**Northeast**	**Southeast**
Alaska	Illinois	Connecticut	Alabama
Arizona	Indiana	Delaware	Arkansas
California	Iowa	Maine	Florida
Colorado	Kansas	Maryland	Georgia
Hawaii	Michigan	Massachusetts	Kentucky
Idaho	Minnesota	New Hampshire	Louisiana
Montana	Missouri	New Jersey	Mississippi
Nevada	Nebraska	New York	North Carolina
New Mexico	North Dakota	Pennsylvania	Oklahoma
Oregon	Ohio	Rhode Island	South Carolina
Utah	South Dakota	Vermont	Tennessee
Washington	Wisconsin	West Virginia	Texas
Wyoming			Virginia

Source: EPA 2020

Appendix Table A-13 Methane Emissions From Cattle Enteric Fermentation, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Animal Type	*MMT CO_2 eq.*										
Dairy	**39.4**	**37.5**	**38.0**	**37.6**	**40.7**	**41.6**	**42.0**	**42.6**	**43.0**	**43.3**	**43.6**
Calves	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5	1.4	1.5	1.5
Cows	31.0	29.6	30.2	29.9	32.2	33.1	33.4	33.9	34.2	34.4	34.8
Replacements 7–11 months	1.5	1.4	1.4	1.4	1.6	1.5	1.6	1.6	1.6	1.6	1.6
Replacements 12–23 months	5.3	5.0	4.9	4.9	5.5	5.5	5.5	5.7	5.8	5.7	5.8
Beef	**119.1**	**135.5**	**126.7**	**125.2**	**124.6**	**118.0**	**116.5**	**118.0**	**123.0**	**126.3**	**128.1**
Bulls	4.9	5.6	5.4	5.4	5.4	5.1	5.0	5.2	5.3	5.5	5.5
Calves	4.6	4.8	4.7	4.5	4.2	3.9	3.9	4.0	4.1	4.2	4.2
Cows	72.1	80.5	76.4	76.4	74.4	70.2	68.8	69.4	71.4	73.9	74.5
Replacements 7–11 months	1.7	2.1	1.9	2.0	1.9	1.9	2.1	2.2	2.3	2.2	2.2
Replacements 12–23 months	4.7	6.0	5.1	5.4	5.3	5.3	5.5	6.0	6.3	6.3	6.0
Steer Stockers	14.1	16.6	12.7	11.8	11.9	10.8	10.6	10.8	11.8	11.5	11.6
Heifer Stockers	7.7	9.4	8.1	7.5	7.5	6.7	6.4	6.6	7.2	7.2	7.4
Total Feedlot Cattle	9.4	10.4	12.5	12.2	14.0	14.2	14.2	13.9	14.7	15.5	16.7
Total	**158.4**	**172.9**	**164.7**	**162.8**	**165.3**	**159.7**	**158.5**	**160.7**	**166.0**	**169.6**	**171.7**

Note: Totals may not sum due to independent rounding.
Source: EPA 2020

Appendix Table A-14 Emission Factors[1] for Livestock

Animal Type	Emission Factors *(kg CH_4/head/year)*
DAIRY	
Calves	12.2
Cows	147.4
Replacements 7–11 months	45.6
Replacements 12–23 months	68.8
BEEF	
Bulls	98.0
Calves	10.5
Cows	94.7
Replacements 7–11 months	60.4
Replacements 12–23 months	69.8
Steer Stockers	58.0
Heifer Stockers	60.2
Total Feedlot	43.0
Sheep	8.0
Horses	18.0
Swine	1.5
Goats	5.0
American Bison	82.2
Mules and Asses	10.0

Note: kg CH_4 is kilograms methane.
Source: EPA 2020, IPCC 2006.
[1] For cattle, emission factors are based on country-specific results from EPA's Cattle Enteric Fermentation Model. For non-cattle livestock, IPCC emission factors are used.

Appendix Table A-15 Summary of Greenhouse Gas Emissions From Managed[1] Manure by State in 2018

State	CH_4	N_2O	***Total***
	MMT CO_2 eq.		
Alabama	0.46	0.14	**0.60**
Alaska	0.01	0.00	**0.01**
Arizona	0.73	0.38	**1.11**
Arkansas	0.29	0.17	**0.46**
California	8.56	1.58	**10.14**
Colorado	0.83	0.86	**1.70**
Connecticut	0.07	0.01	**0.08**
Delaware	0.05	0.03	**0.08**
Florida	0.65	0.06	**0.72**
Georgia	0.93	0.20	**1.14**
Hawaii	0.04	0.01	**0.04**
Idaho	2.50	0.67	**3.17**
Illinois	1.87	0.40	**2.27**
Indiana	1.75	0.37	**2.12**
Iowa	6.53	1.71	**8.23**
Kansas	1.94	1.80	**3.73**
Kentucky	0.36	0.09	**0.45**
Louisiana	0.14	0.02	**0.16**
Maine	0.09	0.02	**0.11**
Maryland	0.19	0.07	**0.25**
Massachusetts	0.02	0.01	**0.02**
Michigan	1.98	0.45	**2.43**
Minnesota	3.12	0.87	**3.99**
Mississippi	0.58	0.11	**0.69**
Missouri	1.66	0.29	**1.95**
Montana	0.21	0.06	**0.27**
Nebraska	1.70	1.91	**3.60**
Nevada	0.18	0.02	**0.20**

	CH_4	N_2O	*Total*
State		*MMT CO_2 eq.*	
New Hampshire	0.04	0.01	**0.05**
New Jersey	0.02	0.01	**0.03**
New Mexico	1.05	0.27	**1.32**
New York	2.28	0.37	**2.65**
North Carolina	4.79	0.42	**5.21**
North Dakota	0.16	0.06	**0.22**
Ohio	1.66	0.41	**2.07**
Oklahoma	1.48	0.34	**1.82**
Oregon	0.34	0.16	**0.50**
Pennsylvania	1.62	0.42	**2.04**
Rhode Island	0.01	0.00	**0.01**
South Carolina	0.30	0.05	**0.35**
South Dakota	1.12	0.42	**1.54**
Tennessee	0.31	0.06	**0.38**
Texas	2.96	2.32	**5.28**
Utah	0.49	0.14	**0.62**
Vermont	0.33	0.06	**0.39**
Virginia	0.44	0.11	**0.55**
Washington	1.13	0.34	**1.47**
West Virginia	0.04	0.02	**0.07**
Wisconsin	3.55	1.07	**4.63**
Wyoming	0.13	0.07	**0.20**
Total	**61.68**	**19.45**	**81.13**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent. CH_4 is methane. N_2O is nitrous oxide.
Source: EPA 2020
[1]Methane totals include emissions from grazed-land manure.

Appendix Table A-16 Methane Emissions From Manure Management by State and Animal in 2018

	Dairy cattle	Beef cattle	Poultry	Swine	Goats	Horses	Sheep	*Total*
State				*MMT CO_2 eq.*				
Alabama	0.0164	0.0644	0.3530	0.0226	0.0005	0.0039	0.0002	**0.4613**
Alaska	0.0002	0.0005	0.0097	0.0001	0.0000	0.0001	0.0002	**0.0109**
Arizona	0.5722	0.0465	0.0315	0.0704	0.0006	0.0062	0.0022	**0.7296**
Arkansas	0.0127	0.0867	0.1347	0.0505	0.0003	0.0035	0.0002	**0.2888**
California	8.2694	0.1386	0.0959	0.0369	0.0012	0.0075	0.0100	**8.5598**
Colorado	0.4279	0.1234	0.1093	0.1618	0.0003	0.0052	0.0052	**0.8339**
Connecticut	0.0654	0.0005	0.0040	0.0003	0.0000	0.0006	0.0001	**0.0708**
Delaware	0.0176	0.0002	0.0280	0.0015	0.0000	0.0002	0.0002	**0.0477**
Florida	0.4199	0.0823	0.1388	0.0037	0.0006	0.0069	0.0002	**0.6528**
Georgia	0.2893	0.0482	0.5642	0.0271	0.0007	0.0039	0.0002	**0.9338**
Hawaii	0.0114	0.0078	0.0145	0.0033	0.0002	0.0004	0.0002	**0.0378**
Idaho	2.4049	0.0585	0.0270	0.0051	0.0002	0.0025	0.0028	**2.5021**
Illinois	0.2962	0.0405	0.0145	1.5124	0.0002	0.0022	0.0006	**1.8667**
Indiana	0.4661	0.0211	0.0464	1.2147	0.0003	0.0041	0.0007	**1.7534**
Iowa	0.8503	0.1411	0.0596	5.4725	0.0005	0.0027	0.0019	**6.5287**
Kansas	0.7824	0.2578	0.0026	0.8889	0.0003	0.0027	0.0008	**1.9358**
Kentucky	0.1309	0.0662	0.0465	0.1059	0.0004	0.0063	0.0007	**0.3572**
Louisiana	0.0276	0.0416	0.0631	0.0013	0.0002	0.0033	0.0002	**0.1375**
Maine	0.0834	0.0010	0.0038	0.0003	0.0000	0.0004	0.0001	**0.0890**
Maryland	0.1409	0.0037	0.0357	0.0041	0.0001	0.0015	0.0002	**0.1863**
Massachusetts	0.0128	0.0005	0.0010	0.0008	0.0000	0.0007	0.0001	**0.0160**
Michigan	1.6225	0.0197	0.0326	0.2976	0.0002	0.0033	0.0009	**1.9770**
Minnesota	1.2396	0.0525	0.0407	1.7821	0.0002	0.0024	0.0015	**3.1192**
Mississippi	0.0181	0.0453	0.2667	0.2510	0.0003	0.0030	0.0002	**0.5848**
Missouri	0.2021	0.1320	0.0502	1.2733	0.0004	0.0043	0.0012	**1.6638**
Montana	0.0378	0.1145	0.0204	0.0337	0.0001	0.0041	0.0026	**0.2145**
Nebraska	0.2846	0.2857	0.0185	1.1044	0.0002	0.0025	0.0009	**1.6982**
Nevada	0.1568	0.0163	0.0016	0.0023	0.0001	0.0007	0.0007	**0.1784**
New Hampshire	0.0336	0.0004	0.0038	0.0003	0.0000	0.0004	0.0001	**0.0386**
New Jersey	0.0157	0.0006	0.0040	0.0012	0.0001	0.0012	0.0002	**0.0230**

State	Dairy cattle	Beef cattle	Poultry	Swine	Goats	Horses	Sheep	*Total*
	MMT CO_2 eq.							
New Mexico	0.9739	0.0375	0.0301	0.0002	0.0002	0.0023	0.0011	**1.0458**
New York	2.2326	0.0132	0.0196	0.0077	0.0002	0.0035	0.0010	**2.2780**
North Carolina	0.1431	0.0357	0.4067	4.2013	0.0005	0.0040	0.0005	**4.7921**
North Dakota	0.0593	0.0644	0.0025	0.0293	0.0000	0.0014	0.0008	**0.1584**
Ohio	0.8337	0.0302	0.0425	0.7501	0.0004	0.0051	0.0014	**1.6637**
Oklahoma	0.0923	0.1621	0.1075	1.1025	0.0009	0.0098	0.0010	**1.4766**
Oregon	0.2549	0.0467	0.0279	0.0015	0.0003	0.0034	0.0019	**0.3368**
Pennsylvania	1.2189	0.0233	0.0445	0.3248	0.0003	0.0045	0.0011	**1.6178**
Rhode Island	0.0015	0.0001	0.0040	0.0002	0.0000	0.0001	0.0001	**0.0059**
South Carolina	0.0461	0.0162	0.1380	0.0978	0.0004	0.0033	0.0002	**0.3022**
South Dakota	0.5216	0.1343	0.0069	0.4474	0.0001	0.0027	0.0029	**1.1172**
Tennessee	0.1020	0.0871	0.0230	0.0935	0.0009	0.0070	0.0008	**0.3149**
Texas	1.5682	0.6662	0.1946	0.4835	0.0078	0.0261	0.0132	**2.9626**
Utah	0.2276	0.0274	0.1055	0.1220	0.0001	0.0028	0.0032	**0.4887**
Vermont	0.3255	0.0018	0.0010	0.0003	0.0001	0.0004	0.0001	**0.3292**
Virginia	0.2161	0.0430	0.0450	0.1346	0.0003	0.0034	0.0009	**0.4434**
Washington	1.0497	0.0329	0.0375	0.0024	0.0002	0.0028	0.0005	**1.1261**
West Virginia	0.0151	0.0135	0.0137	0.0002	0.0002	0.0013	0.0004	**0.0444**
Wisconsin	3.4226	0.0433	0.0164	0.0661	0.0007	0.0038	0.0009	**3.5542**
Wyoming	0.0232	0.0575	0.0263	0.0120	0.0001	0.0029	0.0041	**0.1266**
Total	**32.2366**	**3.4344**	**3.5152**	**22.2076**	**0.0220**	**0.1770**	**0.0717**	**61.6821**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent. Managed manure includes emissions from grazed lands. Bison and mules and asses were not portioned at the State level because emissions were minimal; however, their emissions were included in the total emissions for each State.
Source: EPA 2020

Appendix Table A-17 Nitrous Oxide Emissions from Manure Management by State and Animal in 2018

State	Dairy cattle	Beef cattle	Poultry	Swine	*Total*
	MMT CO_2 eq.				
Alabama	0.0024	0.0039	0.1294	0.0014	**0.1407**
Alaska	0.0001	0.0000	0.0026	0.0000	**0.0033**
Arizona	0.1845	0.1785	0.0027	0.0043	**0.3771**
Arkansas	0.0016	0.0080	0.1583	0.0036	**0.1746**
California	1.2057	0.3092	0.0360	0.0028	**1.5792**
Colorado	0.1575	0.6563	0.0085	0.0230	**0.8636**
Connecticut	0.0096	0.0001	0.0025	0.0000	**0.0136**
Delaware	0.0023	0.0001	0.0277	0.0001	**0.0319**
Florida	0.0375	0.0026	0.0177	0.0002	**0.0630**
Georgia	0.0252	0.0037	0.1678	0.0019	**0.2024**
Hawaii	0.0016	0.0006	0.0026	0.0002	**0.0058**
Idaho	0.4729	0.1868	0.0027	0.0007	**0.6726**
Illinois	0.0594	0.1803	0.0137	0.1435	**0.4041**
Indiana	0.1022	0.0784	0.0703	0.1118	**0.3711**
Iowa	0.1485	0.8292	0.0935	0.6162	**1.7059**
Kansas	0.1128	1.6118	0.0025	0.0627	**1.7986**
Kentucky	0.0177	0.0126	0.0392	0.0079	**0.0886**
Louisiana	0.0028	0.0020	0.0098	0.0001	**0.0175**
Maine	0.0142	0.0003	0.0025	0.0000	**0.0183**
Maryland	0.0238	0.0064	0.0329	0.0004	**0.0660**
Massachusetts	0.0054	0.0001	0.0010	0.0001	**0.0080**
Michigan	0.2679	0.1062	0.0312	0.0333	**0.4486**
Minnesota	0.3226	0.2692	0.0571	0.2110	**0.8744**
Mississippi	0.0028	0.0033	0.0845	0.0162	**0.1099**
Missouri	0.0455	0.0761	0.0642	0.0907	**0.2896**
Montana	0.0103	0.0324	0.0023	0.0052	**0.0603**
Nebraska	0.0357	1.7503	0.0172	0.0938	**1.9066**
Nevada	0.0173	0.0020	0.0025	0.0002	**0.0244**
New Hampshire	0.0061	0.0001	0.0025	0.0000	**0.0099**
New Jersey	0.0030	0.0001	0.0025	0.0001	**0.0081**
New Mexico	0.2541	0.0091	0.0027	0.0000	**0.2708**
New York	0.3286	0.0136	0.0135	0.0009	**0.3686**

	Dairy cattle	Beef cattle	Poultry	Swine	*Total*
State			*MMT CO_2 eq.*		
North Carolina	0.0137	0.0029	0.1376	0.2608	**0.4204**
North Dakota	0.0102	0.0360	0.0025	0.0038	**0.0604**
Ohio	0.1446	0.1074	0.0628	0.0739	**0.4058**
Oklahoma	0.0293	0.2134	0.0252	0.0610	**0.3392**
Oregon	0.0830	0.0590	0.0097	0.0002	**0.1605**
Pennsylvania	0.2414	0.0659	0.0618	0.0355	**0.4188**
Rhode Island	0.0003	0.0000	0.0025	0.0000	**0.0039**
South Carolina	0.0043	0.0009	0.0306	0.0066	**0.0457**
South Dakota	0.0648	0.2766	0.0074	0.0472	**0.4222**
Tennessee	0.0143	0.0102	0.0209	0.0064	**0.0609**
Texas	0.4342	1.7101	0.0961	0.0340	**2.3181**
Utah	0.0851	0.0151	0.0079	0.0166	**0.1357**
Vermont	0.0602	0.0005	0.0010	0.0000	**0.0630**
Virginia	0.0246	0.0145	0.0458	0.0097	**0.1057**
Washington	0.1842	0.1360	0.0152	0.0003	**0.3394**
West Virginia	0.0033	0.0028	0.0128	0.0000	**0.0239**
Wisconsin	0.8458	0.1913	0.0156	0.0085	**1.0719**
Wyoming	0.0036	0.0520	0.0027	0.0021	**0.0737**
Total	**6.1283**	**9.2280**	**1.6621**	**1.9989**	**19.4466**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent. Other animal types were not portioned at the State level because emissions were minimal; however, their emissions were included in the total emissions for each State.
Source: EPA 2020

Appendix Table A-18 Manure Characteristics Data

Animal Group	Average TAM[1] (kg)	Nitrogen, N_{ex}[2] (kg/day per 1,000 kg mass)	Max Methane Generation Potential, B_o (m^3 CH_4/kg VS added)	Volatile Solids, VS (kg/day per 1,000 kg mass)
Dairy Cows	680	0.62	0.24	10.99
Dairy Heifers	406–408	0.50	0.17	10.08
Feedlot Steers	419–457	0.34	0.33	3.97
Feedlot Heifers	384–430	0.35	0.33	4.34
Bulls NOF[3]	831–917	0.21	0.17	5.03
Calves NOF	118	0.45	0.17	7.70
Heifers NOF	296–407	0.32	0.17	4.59
Steers NOF	314–335	0.31	0.17	8.16
Cows NOF	554–611	0.31	0.17	7.66
American Bison	579	0.70	0.17	12.10
Market Swine <50 lbs.	13	0.92	0.48	8.80
Market Swine 50–119 lbs.	39	0.54	0.48	5.40
Market Swine 120–179 lbs.	68	0.54	0.48	5.40
Market Swine >180 lbs.	91	0.54	0.48	5.40
Breeding Swine	198	0.20	0.48	2.70
Sheep	80	0.45	0.19	8.30
Goats	64	0.45	0.17	9.50
Horses	450	0.25	0.33	6.10
Mules and Asses	130	0.30	0.33	7.20
Hens ≥ 1 yr	1.8	0.79	0.39	10.20
Pullets	1.8	0.79	0.39	10.20
Other Chickens	1.8	1.10	0.39	11.00
Broilers	0.9	0.96	0.36	17.00
Turkeys	6.8	0.63	0.36	8.50

Source: EPA 2020.
[1](TAM) Typical animal mass.
[2](N_{ex}) Nitrogen excretion.
[3](NOF) Not on feed.

Appendix Table A-19 State Volatile Solids Production Rates in 2018

	Dairy Cow	Dairy Heifer	Beef Cow NOF[1]	Beef Heifer NOF	Beef Steer NOF	Beef Heifer OF[2]	Beef Steer OF
State				*kg/head/year*			
Alabama	2,262	1,252	1,664	1,100	975	691	669
Alaska	1,821	1,252	1,891	1,252	1,120	691	669
Arizona	2,943	1,252	1,891	1,236	1,120	691	670
Arkansas	2,087	1,252	1,664	1,096	975	691	670
California	2,780	1,252	1,891	1,230	1,120	691	670
Colorado	3,055	1,252	1,891	1,205	1,120	691	669
Connecticut	2,751	1,252	1,674	1,097	981	691	669
Delaware	2,486	1,252	1,674	1,094	981	691	669
Florida	2,657	1,252	1,664	1,103	975	691	668
Georgia	2,790	1,252	1,664	1,093	975	691	668
Hawaii	2,363	1,252	1,891	1,262	1,120	691	669
Idaho	2,920	1,252	1,891	1,220	1,120	691	669
Illinois	2,649	1,252	1,589	1,013	927	691	669
Indiana	2,803	1,252	1,589	1,022	927	691	670
Iowa	2,872	1,252	1,589	995	927	691	670
Kansas	2,817	1,252	1,589	986	927	691	669
Kentucky	2,542	1,252	1,664	1,081	975	691	669
Louisiana	2,100	1,252	1,664	1,103	975	691	669
Maine	2,668	1,252	1,674	1,088	981	691	669
Maryland	2,582	1,252	1,674	1,095	981	691	670
Massachusetts	2,413	1,252	1,674	1,097	981	691	669
Michigan	3,064	1,252	1,589	1,010	927	691	670
Minnesota	2,708	1,252	1,589	1,008	927	691	670
Mississippi	2,291	1,252	1,664	1,098	975	691	669
Missouri	2,189	1,252	1,589	1,033	927	691	669
Montana	2,754	1,252	1,891	1,248	1,120	691	670
Nebraska	2,897	1,252	1,589	991	927	691	670
Nevada	2,754	1,252	1,891	1,244	1,120	691	668
New Hampshire	2,668	1,252	1,674	1,081	981	691	669
New Jersey	2,581	1,252	1,674	1,088	981	691	668
New Mexico	2,964	1,252	1,891	1,237	1,120	691	669
New York	2,887	1,252	1,674	1,078	981	691	668
North Carolina	2,734	1,252	1,664	1,097	975	691	668
North Dakota	2,710	1,252	1,589	1,021	927	691	670
Ohio	2,687	1,252	1,589	1,027	927	691	670
Oklahoma	2,498	1,252	1,664	1,073	975	691	669
Oregon	2,623	1,252	1,891	1,231	1,120	691	669
Pennsylvania	2,656	1,252	1,674	1,083	981	691	669
Rhode Island	2,313	1,252	1,674	1,097	981	691	669
South Carolina	2,384	1,252	1,664	1,100	975	691	671
South Dakota	2,771	1,252	1,589	1,014	927	691	670
Tennessee	2,448	1,252	1,664	1,086	975	691	669
Texas	2,866	1,252	1,664	1,061	975	691	670
Utah	2,841	1,252	1,891	1,244	1,120	691	671
Vermont	2,679	1,252	1,674	1,077	981	691	668
Virginia	2,644	1,252	1,664	1,086	975	691	670
Washington	2,878	1,252	1,891	1,213	1,120	691	670
West Virginia	2,285	1,252	1,674	1,100	981	691	670
Wisconsin	2,872	1,252	1,589	1,033	927	691	670
Wyoming	2,820	1,252	1,891	1,242	1,120	691	669

Source: EPA 2020.
[1](NOF) Not on feed.
[2](OF) On feed.

Appendix Table A-20 State-Based Methane Conversion Factors[1] for Liquid Manure Management Systems in 2018

	Dairy		Swine		Beef	Poultry
	Anaerobic Lagoon	Liquid/Slurry and Deep Pit	Anaerobic Lagoon	Liquid/Slurry and Deep Pit	Liquid/Slurry	Anaerobic Lagoon
State	*percent*					
Alabama	77	42	77	42	44	77
Alaska	49	15	49	15	15	49
Arizona	78	60	76	48	46	75
Arkansas	75	38	76	40	39	75
California	74	33	74	33	45	74
Colorado	66	22	69	25	25	65
Connecticut	71	27	71	27	27	71
Delaware	75	34	75	34	33	75
Florida	79	58	79	56	53	79
Georgia	78	44	77	42	49	77
Hawaii	77	59	77	59	59	77
Idaho	68	24	64	21	22	64
Illinois	73	31	73	31	30	74
Indiana	72	29	72	29	30	72
Iowa	70	27	71	27	27	71
Kansas	74	34	74	33	33	74
Kentucky	75	34	75	35	34	75
Louisiana	78	50	78	49	52	78
Maine	65	22	65	22	21	65
Maryland	74	32	75	33	32	74
Massachusetts	69	25	70	26	26	70
Michigan	69	25	70	26	26	69
Minnesota	68	25	69	25	25	67
Mississippi	77	45	77	44	46	78
Missouri	74	34	74	34	34	74
Montana	59	19	61	20	20	61
Nebraska	71	28	71	28	27	71
Nevada	71	27	71	27	24	73
New Hampshire	66	23	67	23	22	67
New Jersey	73	30	73	31	29	73
New Mexico	73	33	70	28	31	71
New York	68	24	69	25	25	69
North Carolina	76	36	78	41	36	76
North Dakota	65	23	65	23	23	65
Ohio	72	29	72	29	29	72
Oklahoma	76	40	75	37	37	76
Oregon	65	22	64	21	22	64
Pennsylvania	72	28	72	28	28	73
Rhode Island	71	27	71	27	27	71
South Carolina	77	43	78	44	41	77
South Dakota	69	25	69	26	26	69
Tennessee	75	35	76	38	36	75
Texas	75	42	76	44	41	77
Utah	68	23	67	23	24	68
Vermont	65	22	65	22	22	65
Virginia	73	30	76	35	31	74
Washington	64	21	64	21	23	65
West Virginia	72	29	72	29	29	72
Wisconsin	68	24	69	25	25	69
Wyoming	61	20	62	20	21	62

Source: EPA 2020, IPCC 2006.
[1](MCF) Methane conversion factors represent weighted average of multiple animal types.

Appendix Table A-21 Maximum Methane Generation Potential, B0

Animal Group	m^3 CH_4/kg VS added[1]	Source
Dairy Cows	0.24	Morris 1976
Dairy Heifers	0.17	Bryant et al. 1976
Feedlot Steers/Heifers	0.33	Hashimoto 1981
NOF Beef	0.17	Hashimoto 1981
American Bison	0.17	Based on the beef NOF bull B_0
Swine	0.48	Hashimoto 1984
Sheep	0.34	EPA 1992
Goats	0.17	EPA 1992
Horses	0.33	EPA 1992
Mules	0.33	Based on the horse B_0
Broilers	0.36	Hill 1984
Other Chickens	0.39	Hill 1982
Turkeys	0.36	Hill 1984

Source: EPA 2020, IPCC 2006.

[1] m^3 CH_4/kg VS added is cubic meter methane per kilogram of volatile solids.

Appendix Table A-22 Methane Conversion Factors for Dry Systems

	Cool Climate MCF[1]	Temperate Climate MCF	Warm Climate MCF
Manure Management System		*percent*	
Aerobic Treatment	0	0	0
Anaerobic Digester	0	0	0
Cattle Deep Litter (<1 month)	3	3	30
Cattle Deep Litter (>1 month)	21	44	76
Composting-In Vessel	0.5	0.5	0.5
Composting-Static Pile	0.5	0.5	0.5
Composting-Extensive/Passive	0.5	1	1.5
Composting-Intensive	0.5	1	1.5
Daily Spread	0.1	0.5	1
Dry Lot	1	1.5	5
Fuel	10	10	10
Pasture	1	1.5	2
Poultry with bedding	1.5	1.5	1.5
Poultry without bedding	1.5	1.5	1.5
Solid Storage	2	4	5

Source: EPA 2020, IPCC 2006.

[1] MCF is methane conversion factor.

Appendix Table A-23 Methane Conversion Factors for Livestock Manure Emissions in 2018

	Beef Feedlot Heifer	Beef Feedlot Steer	Dairy Cow	Dairy Heifer	Swine Market	Swine Breeding	Layer	Broiler	Turkey	Sheep	Goats	Horses
State						*percent*						
Alabama	2.1	2.1	25.4	1.9	46.5	46.5	33.3	1.5	1.5	1.5	1.5	1.5
Alaska	1.2	1.2	9.3	1.2	8.0	8.0	13.4	1.5	1.5	1.0	1.0	1.0
Arizona	1.7	1.7	24.4	1.7	47.5	47.5	45.4	1.5	1.5	1.5	1.5	1.5
Arkansas	2.0	2.0	24.9	1.9	45.6	45.6	1.5	1.5	1.5	1.5	1.5	1.5
California	2.1	2.1	42.0	1.8	40.2	40.1	10.2	1.5	1.5	1.5	1.5	1.5
Colorado	1.1	1.1	22.3	1.1	24.4	24.4	39.9	1.5	1.5	1.0	1.0	1.0
Connecticut	1.3	1.3	31.0	1.2	10.3	10.3	5.0	1.5	1.5	1.0	1.0	1.0
Delaware	1.3	1.3	35.1	1.3	26.3	26.3	5.2	1.5	1.5	1.0	1.0	1.0
Florida	2.2	2.2	32.1	2.1	29.9	29.9	34.1	1.5	1.5	1.5	1.5	1.5
Georgia	2.1	2.1	30.9	1.9	46.5	46.5	33.1	1.5	1.5	1.5	1.5	1.5
Hawaii	2.3	2.3	49.8	2.1	37.7	37.7	20.5	1.5	1.5	1.5	1.5	1.5
Idaho	1.1	1.1	34.1	1.1	19.0	19.0	38.7	1.5	1.5	1.0	1.0	1.0
Illinois	1.2	1.2	29.8	1.2	33.7	33.7	2.9	1.5	1.5	1.0	1.0	1.0
Indiana	1.2	1.2	22.3	1.1	34.3	34.3	1.5	1.5	1.5	1.0	1.0	1.0
Iowa	1.2	1.2	34.1	1.1	28.8	28.8	1.5	1.5	1.5	1.0	1.0	1.0

State	Beef Feedlot Heifer	Beef Feedlot Steer	Dairy Cow	Dairy Heifer	Swine Market	Swine Breeding	Layer	Broiler	Turkey	Sheep	Goats	Horses
						percent						
Kansas	1.2	1.2	45.9	1.2	46.8	46.8	3.0	1.5	1.5	1.0	1.0	1.0
Kentucky	1.3	1.3	22.2	1.3	41.1	41.1	5.0	1.5	1.5	1.0	1.0	1.0
Louisiana	2.2	2.2	27.0	2.0	19.9	19.9	47.1	1.5	1.5	1.5	1.5	1.5
Maine	1.2	1.2	25.8	1.2	6.7	6.7	4.7	1.5	1.5	1.0	1.0	1.0
Maryland	1.3	1.3	28.7	1.3	22.1	22.1	5.0	1.5	1.5	1.0	1.0	1.0
Massachusetts	1.3	1.3	11.2	1.2	11.9	11.9	4.9	1.5	1.5	1.0	1.0	1.0
Michigan	1.2	1.2	31.0	1.1	27.9	27.9	2.9	1.5	1.5	1.0	1.0	1.0
Minnesota	1.2	1.2	24.6	1.1	26.2	26.2	1.5	1.5	1.5	1.0	1.0	1.0
Mississippi	2.1	2.1	21.4	2.0	54.3	54.3	47.2	1.5	1.5	1.5	1.5	1.5
Missouri	1.2	1.2	26.9	1.2	45.3	45.3	1.5	1.5	1.5	1.0	1.0	1.0
Montana	1.1	1.1	24.3	1.1	20.3	20.3	37.2	1.5	1.5	1.0	1.0	1.0
Nebraska	1.2	1.2	40.7	1.1	36.9	36.9	2.9	1.5	1.5	1.0	1.0	1.0
Nevada	1.1	1.1	47.2	1.1	37.7	38.1	1.5	1.5	1.5	1.0	1.0	1.0
New Hampshire	1.2	1.2	23.1	1.2	9.4	9.4	4.8	1.5	1.5	1.0	1.0	1.0
New Jersey	1.3	1.3	23.1	1.2	15.7	15.7	5.1	1.5	1.5	1.0	1.0	1.0
New Mexico	1.1	1.1	25.1	1.1	13.8	13.8	43.4	1.5	1.5	1.0	1.0	1.0
New York	1.2	1.2	30.9	1.2	16.5	16.5	4.9	1.5	1.5	1.0	1.0	1.0
North Carolina	1.9	1.9	28.7	1.8	57.2	57.2	32.7	1.5	1.5	1.5	1.5	1.5
North Dakota	1.1	1.1	33.9	1.1	23.2	23.2	2.8	1.5	1.5	1.0	1.0	1.0
Ohio	1.2	1.2	29.4	1.1	32.7	32.7	1.5	1.5	1.5	1.0	1.0	1.0
Oklahoma	1.1	1.1	26.0	1.6	56.5	56.5	46.0	1.5	1.5	1.5	1.5	1.5
Oregon	1.3	1.3	19.3	1.2	17.2	17.2	17.1	1.5	1.5	1.0	1.0	1.0
Pennsylvania	1.3	1.3	21.6	1.2	28.8	28.8	1.5	1.5	1.5	1.0	1.0	1.0
Rhode Island	1.3	1.3	19.7	1.2	11.1	11.1	5.0	1.5	1.5	1.0	1.0	1.0
South Carolina	2.0	2.0	31.8	1.9	50.3	50.3	46.8	1.5	1.5	1.5	1.5	1.5
South Dakota	1.2	1.2	40.3	1.1	30.4	30.4	2.8	1.5	1.5	1.0	1.0	1.0
Tennessee	1.9	1.9	25.0	1.3	48.1	48.1	5.2	1.5	1.5	1.5	1.5	1.5
Texas	1.7	1.7	27.6	1.6	47.0	47.0	10.5	1.5	1.5	1.5	1.5	1.5
Utah	1.1	1.1	21.5	1.1	23.9	23.9	41.6	1.5	1.5	1.0	1.0	1.0
Vermont	1.2	1.2	23.3	1.2	8.0	8.0	4.7	1.5	1.5	1.0	1.0	1.0
Virginia	1.3	1.3	23.3	1.2	44.9	45.0	5.1	1.5	1.5	1.0	1.0	1.0
Washington	1.3	1.3	32.9	1.2	15.1	15.1	9.1	1.5	1.5	1.0	1.0	1.0
West Virginia	1.3	1.3	20.4	1.2	6.0	6.0	5.0	1.5	1.5	1.0	1.0	1.0
Wisconsin	1.1	1.1	23.0	1.1	22.0	22.0	2.8	1.5	1.5	1.0	1.0	1.0
Wyoming	1.1	1.1	34.0	1.1	16.1	16.1	37.8	1.5	1.5	1.0	1.0	1.0

Note: Methane conversion factors are weighted by the distribution of manure management systems for each animal type within a State.
Source: EPA 2020

Appendix Table A-24 Direct Nitrous Oxide Emission Factors for 2018

Manure Management System	Direct N_2O Emission Factor
	kg N_2O-N/kg Kjdl N[1]
Aerobic Treatment (forced aeration)	0.005
Aerobic Treatment (natural aeration)	0.01
Anaerobic Digester	0
Anaerobic Lagoon	0
Cattle Deep Bed (active mix)	0.07
Cattle Deep Bed (no mix)	0.01
Composting in vessel	0.006
Composting intensive	0.1
Composting passive	0.01
Composting static	0.006
Daily Spread	0
Deep Pit	0.002
Dry Lot	0.02
Fuel	0
Liquid/Slurry	0.005
Pasture	0
Poultry with bedding	0.001
Poultry without bedding	0.001
Solid Storage	0.005

Note: N_2O is nitrous oxide.
Source: EPA 2020, IPCC 2006.
[1] kg N_2O-N/kg Kjdl N is kilograms nitrogen in nitrous oxide per kilograms Kjeldahl nitrogen.

Appendix Table A-25 State-Level Estimates of N2O Emissions From Grazed Lands, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Nitrous Oxide[1]						*MMT CO_2 eq.*					
Alabama	**0.7**	**0.8**	**0.8**	**1.0**	**1.0**	**1.2**	**1.0**	**1.2**	**1.2**	**1.2**	**1.2**
Direct	0.5	0.6	0.6	0.8	0.8	0.9	0.8	0.9	0.9	0.9	0.9
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.3	0.3
Arizona	**3.9**	**3.1**	**2.9**	**3.2**	**3.5**	**3.5**	**3.4**	**3.8**	**3.4**	**3.4**	**3.4**
Direct	3.8	3.0	2.8	3.1	3.4	3.4	3.3	3.7	3.3	3.3	3.3
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**1.1**	**1.0**	**1.1**	**1.1**	**1.2**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.5**
Direct	0.8	0.8	0.9	0.9	0.9	1.0	1.2	1.0	1.1	1.1	1.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3
California	**2.1**	**2.1**	**1.9**	**2.1**	**2.2**	**1.5**	**1.9**	**2.1**	**1.8**	**1.8**	**1.8**
Direct	1.9	1.8	1.7	1.9	1.9	1.4	1.7	1.9	1.6	1.6	1.6
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Leaching & Runoff	0.1	0.2	0.2	0.2	0.2	0.0	0.2	0.1	0.2	0.1	0.2
Colorado	**4.2**	**3.9**	**3.5**	**4.2**	**4.0**	**4.7**	**4.5**	**4.4**	**4.3**	**4.2**	**4.3**
Direct	4.0	3.7	3.4	4.0	3.8	4.5	4.3	4.2	4.1	4.0	4.1
Indirect Volatilization	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Connecticut	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florida	**1.1**	**1.4**	**1.2**	**1.6**	**1.4**	**1.6**	**1.6**	**1.7**	**1.7**	**1.7**	**1.7**
Direct	0.9	1.0	0.9	1.1	1.0	1.1	1.2	1.2	1.2	1.2	1.2
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.2	0.3	0.2	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Georgia	**0.5**	**0.6**	**0.7**	**0.8**	**0.7**	**0.8**	**0.7**	**0.8**	**0.8**	**0.8**	**0.9**
Direct	0.4	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Idaho	**0.8**	**0.9**	**0.8**	**1.0**	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
Direct	0.8	0.9	0.8	1.0	0.8	1.0	1.0	1.0	0.9	0.9	0.9
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illinois	**1.0**	**0.8**	**0.8**	**0.7**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**
Direct	0.8	0.7	0.7	0.6	0.8	0.7	0.8	0.8	0.7	0.7	0.7
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Indiana	**0.7**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Direct	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Iowa	**1.8**	**1.6**	**1.4**	**1.6**	**2.0**	**1.6**	**2.0**	**2.1**	**1.8**	**1.8**	**1.8**
Direct	1.6	1.3	1.3	1.4	1.7	1.3	1.8	1.8	1.5	1.5	1.5
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.3	0.3	0.3	0.3
Kansas	**4.1**	**4.3**	**3.8**	**5.0**	**5.1**	**5.4**	**5.1**	**5.0**	**4.9**	**4.9**	**4.9**
Direct	3.7	3.9	3.5	4.6	4.7	5.0	4.7	4.6	4.5	4.4	4.5
Indirect Volatilization	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.3
Kentucky	**1.8**	**1.7**	**1.8**	**1.6**	**1.9**	**2.0**	**2.0**	**2.3**	**2.1**	**2.1**	**2.1**
Direct	1.4	1.4	1.5	1.3	1.7	1.6	1.7	1.9	1.7	1.7	1.7
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.3	0.3	0.3	0.2	0.2	0.4	0.3	0.4	0.4	0.4	0.4
Louisiana	**0.7**	**0.8**	**0.7**	**0.8**	**0.8**	**0.9**	**0.9**	**0.9**	**1.0**	**1.0**	**1.0**
Direct	0.6	0.7	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Maine	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Direct	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Direct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Massachusetts	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**0.5**	**0.5**	**0.6**	**0.6**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
Direct	0.3	0.4	0.4	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2
Minnesota	**1.0**	**1.2**	**1.0**	**1.3**	**1.5**	**1.2**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**
Direct	0.9	1.0	0.9	1.1	1.2	1.0	1.2	1.2	1.1	1.1	1.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
Mississippi	**0.4**	**0.5**	**0.5**	**0.7**	**0.7**	**0.9**	**0.9**	**0.8**	**0.9**	**0.9**	**0.9**
Direct	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.7
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Missouri	**3.2**	**2.9**	**2.9**	**2.9**	**3.6**	**3.2**	**3.2**	**3.5**	**3.3**	**3.2**	**3.3**
Direct	2.7	2.4	2.6	2.4	3.0	2.6	2.7	2.9	2.6	2.6	2.6
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Leaching & Runoff	0.5	0.4	0.2	0.4	0.4	0.5	0.4	0.5	0.6	0.6	0.6
Montana	**5.8**	**6.6**	**5.4**	**6.9**	**7.4**	**7.8**	**7.7**	**6.7**	**6.7**	**6.7**	**6.7**
Direct	5.7	6.4	5.2	6.7	7.2	7.6	7.5	6.5	6.5	6.4	6.5
Indirect Volatilization	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska	**4.1**	**4.0**	**3.5**	**4.7**	**4.9**	**4.9**	**5.0**	**4.9**	**4.3**	**4.3**	**4.3**
Direct	3.9	3.8	3.4	4.5	4.6	4.6	4.8	4.7	4.1	4.1	4.1
Indirect Volatilization	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Nevada	**0.6**	**0.7**	**0.7**	**0.9**	**0.8**	**0.8**	**0.9**	**1.1**	**0.8**	**0.8**	**0.8**
Direct	0.6	0.7	0.7	0.9	0.8	0.8	0.8	1.0	0.8	0.8	0.8

Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Mexico	**5.9**	**5.2**	**4.5**	**5.9**	**6.0**	**6.4**	**6.0**	**6.6**	**5.9**	**5.8**	**5.9**
Direct	5.7	5.0	4.3	5.6	5.8	6.1	5.7	6.4	5.6	5.6	5.6
Indirect Volatilization	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	**0.6**	**0.6**	**0.8**	**0.8**	**1.0**	**1.1**	**1.0**	**1.0**	**1.1**	**1.1**	**1.1**
Direct	0.5	0.4	0.6	0.6	0.8	0.9	0.8	0.8	0.8	0.8	0.8
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3
North Carolina	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Direct	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
North Dakota	**1.8**	**2.1**	**1.8**	**2.3**	**2.4**	**2.5**	**2.6**	**2.0**	**2.1**	**2.1**	**2.1**
Direct	1.8	2.1	1.8	2.2	2.4	2.4	2.5	2.0	2.1	2.1	2.1
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ohio	**0.6**	**0.5**	**0.7**	**0.6**	**0.7**	**0.8**	**0.7**	**0.7**	**0.8**	**0.7**	**0.8**
Direct	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Oklahoma	**3.9**	**4.2**	**4.1**	**4.3**	**4.7**	**5.1**	**4.6**	**5.3**	**4.9**	**4.9**	**5.0**
Direct	3.3	3.6	3.5	3.8	4.0	4.4	4.1	4.4	4.1	4.1	4.2
Indirect Volatilization	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Leaching & Runoff	0.5	0.5	0.5	0.4	0.5	0.5	0.3	0.7	0.6	0.6	0.6
Oregon	**1.0**	**1.1**	**1.1**	**1.1**	**1.3**	**1.3**	**1.2**	**1.1**	**1.2**	**1.2**	**1.2**
Direct	0.9	1.0	1.0	1.0	1.1	1.2	1.1	1.0	1.1	1.0	1.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pennsylvania	**0.5**	**0.4**	**0.5**	**0.5**	**0.6**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
Direct	0.4	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Rhode Island	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**
Direct	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
South Dakota	**4.0**	**4.5**	**3.2**	**4.4**	**5.0**	**5.0**	**5.0**	**4.7**	**4.4**	**4.3**	**4.4**
Direct	3.8	4.3	3.1	4.2	4.8	4.8	4.8	4.5	4.2	4.2	4.2
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Leaching & Runoff	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Tennessee	**1.3**	**1.5**	**1.4**	**1.5**	**1.5**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.8**
Direct	1.0	1.2	1.1	1.2	1.3	1.3	1.4	1.3	1.3	1.3	1.3
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4
Texas	**16.8**	**15.8**	**15.3**	**15.2**	**15.6**	**15.3**	**15.4**	**16.7**	**15.9**	**15.8**	**16.0**
Direct	15.6	14.6	14.1	14.0	14.4	14.1	14.5	15.2	14.4	14.3	14.5
Indirect Volatilization	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6
Indirect Leaching & Runoff	0.6	0.6	0.7	0.5	0.6	0.5	0.4	0.9	0.9	0.9	0.9
Utah	**1.0**	**1.1**	**1.0**	**1.3**	**1.2**	**1.2**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**
Direct	0.9	1.1	1.0	1.3	1.1	1.2	1.2	1.2	1.1	1.1	1.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vermont	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Direct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	**1.1**	**1.1**	**1.3**	**1.2**	**1.1**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**
Direct	0.9	0.9	1.1	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Washington	**0.9**	**0.8**	**0.7**	**0.8**	**1.0**	**0.9**	**1.0**	**0.7**	**0.8**	**0.8**	**0.8**
Direct	0.8	0.7	0.6	0.8	0.9	0.8	0.9	0.6	0.7	0.7	0.8
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1
West Virginia	**0.2**	**0.3**	**0.3**	**0.3**	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Direct	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wisconsin	**0.9**	**0.9**	**0.9**	**1.0**	**1.2**	**1.0**	**1.1**	**1.2**	**1.1**	**1.1**	**1.1**
Direct	0.7	0.7	0.8	0.8	1.0	0.8	0.9	0.9	0.8	0.8	0.8
Indirect Volatilization	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Leaching & Runoff	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wyoming	**3.4**	**3.6**	**2.7**	**3.6**	**3.1**	**4.0**	**4.5**	**3.8**	**3.7**	**3.7**	**3.7**
Direct	3.3	3.5	2.6	3.4	2.9	3.8	4.3	3.7	3.6	3.5	3.6
Indirect Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Indirect Leaching & Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1] Estimates only includes area of grazed lands estimated with Tier 3 method; see table A-27 for more information.

Appendix Table A-26 State-Level Estimates of Annual Soil Carbon Stock Changes From Grazed Lands, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Carbon Dioxide[1]						*MMT CO_2 eq.*					
Alabama	**(1.4)**	**(1.1)**	**(1.7)**	**(1.4)**	**(1.1)**	**(1.0)**	**(0.9)**	**(1.0)**	**(0.8)**	**(0.8)**	**(0.8)**
Grazed Lands Remaining Grazed	(0.4)	(0.3)	(0.3)	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(1.0)	(0.9)	(1.3)	(1.2)	(0.9)	(0.8)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)
Arizona	**1.9**	**(1.2)**	**(1.2)**	**(1.3)**	**(1.5)**	**(0.7)**	**(0.2)**	**(0.3)**	**(0.5)**	**(0.5)**	**(0.5)**
Grazed Lands Remaining Grazed	2.1	(0.6)	0.1	0.2	(0.0)	0.6	0.8	0.6	0.6	0.6	0.6
Land Converted to Grazed Land	(0.2)	(0.6)	(1.3)	(1.5)	(1.4)	(1.3)	(1.0)	(0.9)	(1.1)	(1.1)	(1.1)
Arkansas	**(0.9)**	**(0.7)**	**(0.7)**	**(1.0)**	**(0.8)**	**(0.4)**	**(0.3)**	**(0.7)**	**(0.5)**	**(0.5)**	**(0.5)**
Grazed Lands Remaining Grazed	(0.7)	(0.5)	(0.3)	(0.5)	(0.3)	0.0	0.1	(0.3)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(0.2)	(0.3)	(0.4)	(0.5)	(0.5)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
California	**0.0**	**(1.6)**	**(5.2)**	**(5.5)**	**(5.6)**	**(5.7)**	**(5.3)**	**(3.6)**	**(4.7)**	**(4.7)**	**(4.7)**

Grazed Lands Remaining Grazed	0.4	0.6	0.1	0.4	0.3	(0.4)	(0.6)	0.4	(0.2)	(0.2)	(0.2)
Land Converted to Grazed Land	(0.4)	(2.2)	(5.3)	(5.9)	(5.9)	(5.3)	(4.7)	(4.0)	(4.6)	(4.6)	(4.6)
Colorado	**0.7**	**(0.8)**	**(2.7)**	**(2.4)**	**(3.0)**	**(2.6)**	**(2.2)**	**(2.2)**	**(2.5)**	**(2.5)**	**(2.5)**
Grazed Lands Remaining Grazed	0.8	0.3	(0.0)	0.5	0.1	0.5	0.4	0.1	0.1	0.1	0.1
Land Converted to Grazed Land	(0.1)	(1.1)	(2.7)	(3.0)	(3.1)	(3.1)	(2.7)	(2.4)	(2.6)	(2.6)	(2.6)
Connecticut	**(0.0)**	**(0.0)**	**(0.1)**	**(0.0)**	**(0.0)**	**(0.1)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Delaware	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.1)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	0.0	(0.0)	(0.0)	(0.0)	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Florida	**0.9**	**1.0**	**0.5**	**0.2**	**0.3**	**0.0**	**0.2**	**0.2**	**(0.1)**	**(0.1)**	**(0.1)**
Grazed Lands Remaining Grazed	1.5	1.8	1.4	1.0	1.1	0.9	1.0	1.0	0.7	0.7	0.7
Land Converted to Grazed Land	(0.6)	(0.9)	(0.9)	(0.8)	(0.8)	(0.9)	(0.8)	(0.9)	(0.8)	(0.8)	(0.8)
Georgia	**(1.1)**	**(1.1)**	**(1.2)**	**(1.1)**	**(0.8)**	**(0.6)**	**(0.4)**	**(0.6)**	**(0.5)**	**(0.5)**	**(0.5)**
Grazed Lands Remaining Grazed	(0.3)	(0.2)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.2)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.8)	(0.9)	(1.1)	(1.0)	(0.8)	(0.6)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
Hawaii	**0.6**	**0.5**	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.3**	**0.3**	**0.4**
Grazed Lands Remaining Grazed	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4
Land Converted to Grazed Land	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Idaho	**(0.1)**	**(1.6)**	**(3.9)**	**(2.8)**	**(3.0)**	**(3.1)**	**(1.5)**	**(2.0)**	**(2.2)**	**(2.2)**	**(2.2)**
Grazed Lands Remaining Grazed	0.0	(0.7)	(1.7)	(0.4)	(0.5)	(0.7)	0.6	(0.3)	(0.2)	(0.2)	(0.2)
Land Converted to Grazed Land	(0.1)	(0.9)	(2.2)	(2.4)	(2.5)	(2.4)	(2.0)	(1.8)	(2.0)	(2.0)	(2.0)
Illinois	**(0.6)**	**(0.7)**	**(1.0)**	**(1.0)**	**(0.7)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.6)**
Grazed Lands Remaining Grazed	(0.2)	(0.3)	(0.2)	(0.2)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.4)	(0.4)	(0.8)	(0.8)	(0.7)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)
Indiana	**(0.7)**	**(0.7)**	**(0.9)**	**(1.0)**	**(0.7)**	**(0.3)**	**(0.3)**	**(0.5)**	**(0.4)**	**(0.4)**	**(0.4)**
Grazed Lands Remaining Grazed	(0.1)	(0.1)	(0.0)	(0.1)	0.1	0.1	0.1	(0.1)	0.0	0.0	0.0
Land Converted to Grazed Land	(0.6)	(0.7)	(0.9)	(0.9)	(0.7)	(0.5)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
Iowa	**(1.3)**	**(1.0)**	**(1.2)**	**(1.1)**	**(1.0)**	**(1.0)**	**(0.9)**	**(1.2)**	**(0.9)**	**(0.9)**	**(0.9)**
Grazed Lands Remaining Grazed	(0.7)	(0.5)	(0.5)	(0.4)	(0.2)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
Land Converted to Grazed Land	(0.7)	(0.5)	(0.7)	(0.6)	(0.8)	(0.6)	(0.6)	(0.8)	(0.6)	(0.7)	(0.6)
Kansas	**(1.4)**	**(1.1)**	**(2.2)**	**(1.3)**	**(1.1)**	**(1.2)**	**(1.3)**	**(1.3)**	**(1.2)**	**(1.2)**	**(1.2)**
Grazed Lands Remaining Grazed	(0.8)	(0.4)	(1.2)	(0.3)	(0.1)	(0.2)	(0.3)	(0.3)	(0.2)	(0.3)	(0.3)
Land Converted to Grazed Land	(0.6)	(0.7)	(0.9)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	(0.9)	(0.9)	(0.9)
Kentucky	**(2.3)**	**(2.6)**	**(2.1)**	**(1.9)**	**(1.4)**	**(0.6)**	**(0.7)**	**(0.8)**	**(0.7)**	**(0.7)**	**(0.7)**
Grazed Lands Remaining Grazed	(0.4)	(0.3)	(0.0)	(0.3)	(0.3)	0.0	(0.1)	(0.2)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(1.9)	(2.3)	(2.1)	(1.6)	(1.1)	(0.6)	(0.5)	(0.6)	(0.6)	(0.6)	(0.6)
Louisiana	**(0.7)**	**(0.7)**	**(0.9)**	**(0.8)**	**(0.8)**	**(0.4)**	**(0.1)**	**(0.5)**	**(0.4)**	**(0.4)**	**(0.4)**
Grazed Lands Remaining Grazed	(0.1)	0.0	(0.2)	(0.0)	(0.1)	0.1	0.3	(0.0)	0.1	0.1	0.1
Land Converted to Grazed Land	(0.6)	(0.7)	(0.7)	(0.7)	(0.7)	(0.5)	(0.5)	(0.5)	(0.4)	(0.4)	(0.4)
Maine	**(0.0)**	**(0.0)**	**0.0**	**(0.1)**	**(0.0)**	**(0.1)**	**0.0**	**0.0**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	0.1	0.0	0.0	0.0
Land Converted to Grazed Land	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Maryland	**(0.2)**	**(0.2)**	**(0.2)**	**(0.2)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**
Grazed Lands Remaining Grazed	(0.0)	(0.0)	0.0	(0.0)	0.0	0.0	0.0	(0.0)	0.0	0.0	0.0
Land Converted to Grazed Land	(0.2)	(0.2)	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Massachusetts	**0.0**	**(0.0)**	**0.0**	**(0.0)**	**0.0**	**0.0**	**0.0**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	0.0	(0.0)	0.0	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Michigan	**(0.3)**	**(0.4)**	**(0.7)**	**(1.1)**	**(0.5)**	**(0.4)**	**(0.3)**	**(0.3)**	**(0.4)**	**(0.4)**	**(0.4)**
Grazed Lands Remaining Grazed	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.2	0.2
Land Converted to Grazed Land	(0.7)	(0.7)	(1.1)	(1.3)	(0.9)	(0.6)	(0.5)	(0.5)	(0.6)	(0.6)	(0.6)

Minnesota	**0.8**	**0.8**	**0.2**	**0.6**	**1.1**	**0.8**	**1.3**	**1.2**	**0.7**	**0.7**	**0.8**
Grazed Lands Remaining Grazed	1.3	1.2	0.9	1.2	1.3	1.1	1.5	1.4	1.0	1.0	1.0
Land Converted to Grazed Land	(0.5)	(0.4)	(0.7)	(0.6)	(0.2)	(0.3)	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)
Mississippi	**(1.3)**	**(1.2)**	**(1.2)**	**(0.9)**	**(0.8)**	**(0.5)**	**(0.3)**	**(0.7)**	**(0.4)**	**(0.4)**	**(0.4)**
Grazed Lands Remaining Grazed	(0.2)	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	0.0	(0.3)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(1.1)	(1.1)	(1.1)	(0.8)	(0.5)	(0.4)	(0.3)	(0.4)	(0.4)	(0.4)	(0.4)
Missouri	**(2.8)**	**(2.2)**	**(2.5)**	**(2.3)**	**(1.0)**	**(0.8)**	**(1.1)**	**(0.8)**	**(0.9)**	**(0.9)**	**(0.9)**
Grazed Lands Remaining Grazed	(1.0)	(0.6)	(0.8)	(0.8)	(0.0)	(0.2)	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)
Land Converted to Grazed Land	(1.8)	(1.6)	(1.7)	(1.5)	(1.0)	(0.6)	(0.7)	(0.5)	(0.6)	(0.6)	(0.6)
Montana	**3.1**	**0.5**	**(1.8)**	**0.1**	**8.2**	**5.7**	**2.4**	**1.3**	**0.8**	**0.8**	**0.9**
Grazed Lands Remaining Grazed	3.2	1.0	(1.0)	1.1	9.2	6.6	3.1	2.1	1.6	1.6	1.7
Land Converted to Grazed Land	(0.1)	(0.6)	(0.8)	(1.0)	(1.0)	(0.9)	(0.7)	(0.8)	(0.8)	(0.8)	(0.8)
Nebraska	**(0.7)**	**(1.2)**	**(2.8)**	**(0.8)**	**(0.9)**	**(1.7)**	**(0.6)**	**(1.1)**	**(1.1)**	**(1.1)**	**(1.2)**
Grazed Lands Remaining Grazed	(0.4)	(1.0)	(2.3)	(0.2)	(0.3)	(1.1)	(0.1)	(0.5)	(0.6)	(0.6)	(0.7)
Land Converted to Grazed Land	(0.3)	(0.3)	(0.5)	(0.6)	(0.6)	(0.6)	(0.5)	(0.6)	(0.5)	(0.5)	(0.5)
Nevada	**0.1**	**(0.9)**	**(1.1)**	**(2.8)**	**(2.4)**	**(1.9)**	**(1.4)**	**(1.4)**	**(1.7)**	**(1.7)**	**(1.7)**
Grazed Lands Remaining Grazed	0.0	0.1	1.2	(0.1)	0.4	0.5	0.4	0.3	0.2	0.2	0.2
Land Converted to Grazed Land	0.0	(1.0)	(2.3)	(2.7)	(2.8)	(2.3)	(1.8)	(1.7)	(2.0)	(2.0)	(2.0)
New Hampshire	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**(0.0)**	**0.0**	**0.0**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
New Jersey	**(0.0)**	**(0.0)**	**(0.0)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**
Grazed Lands Remaining Grazed	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	(0.0)	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
New Mexico	**1.1**	**0.7**	**0.4**	**1.8**	**3.1**	**2.3**	**3.8**	**3.0**	**1.3**	**1.3**	**1.4**
Grazed Lands Remaining Grazed	1.3	1.3	1.7	3.3	4.5	3.8	5.1	4.2	2.5	2.5	2.7
Land Converted to Grazed Land	(0.2)	(0.6)	(1.3)	(1.5)	(1.4)	(1.5)	(1.3)	(1.2)	(1.3)	(1.3)	(1.3)
New York	**(0.3)**	**(0.5)**	**(0.6)**	**(0.9)**	**(0.5)**	**(0.3)**	**(0.1)**	**(0.1)**	**(0.2)**	**(0.2)**	**(0.2)**
Grazed Lands Remaining Grazed	(0.1)	(0.1)	(0.1)	(0.2)	(0.0)	0.0	0.1	0.1	0.1	0.1	0.1
Land Converted to Grazed Land	(0.2)	(0.4)	(0.6)	(0.7)	(0.5)	(0.3)	(0.2)	(0.2)	(0.3)	(0.3)	(0.2)
North Carolina	**(0.6)**	**(0.6)**	**(0.7)**	**(0.8)**	**(0.9)**	**(0.6)**	**(0.5)**	**(0.6)**	**(0.5)**	**(0.5)**	**(0.5)**
Grazed Lands Remaining Grazed	(0.1)	0.0	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.5)	(0.6)	(0.7)	(0.7)	(0.8)	(0.5)	(0.5)	(0.6)	(0.5)	(0.5)	(0.5)
North Dakota	**(0.3)**	**0.1**	**(1.1)**	**(0.5)**	**(0.6)**	**(1.1)**	**(1.0)**	**(1.7)**	**(1.3)**	**(1.3)**	**(1.3)**
Grazed Lands Remaining Grazed	(0.0)	0.5	(0.4)	0.3	0.5	0.1	0.2	(0.3)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(0.3)	(0.4)	(0.7)	(0.9)	(1.0)	(1.3)	(1.2)	(1.4)	(1.2)	(1.2)	(1.2)
Ohio	**(0.9)**	**(0.8)**	**(1.4)**	**(1.3)**	**(0.9)**	**(0.8)**	**(0.8)**	**(0.8)**	**(0.8)**	**(0.8)**	**(0.8)**
Grazed Lands Remaining Grazed	(0.2)	(0.1)	(0.2)	(0.2)	(0.0)	0.0	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.7)	(0.7)	(1.2)	(1.1)	(0.9)	(0.8)	(0.8)	(0.8)	(0.7)	(0.7)	(0.7)
Oklahoma	**(2.3)**	**(1.2)**	**(2.8)**	**(1.8)**	**(2.0)**	**(2.0)**	**(1.4)**	**(1.4)**	**(1.4)**	**(1.4)**	**(1.4)**
Grazed Lands Remaining Grazed	(1.2)	(0.1)	(0.9)	(0.1)	(0.6)	(0.5)	(0.2)	(0.1)	(0.2)	(0.2)	(0.2)
Land Converted to Grazed Land	(1.2)	(1.2)	(1.9)	(1.7)	(1.4)	(1.5)	(1.2)	(1.3)	(1.2)	(1.3)	(1.2)
Oregon	**(0.3)**	**(1.1)**	**(1.9)**	**(2.3)**	**(2.2)**	**(1.9)**	**(1.3)**	**(1.7)**	**(1.5)**	**(1.5)**	**(1.5)**
Grazed Lands Remaining Grazed	(0.1)	(0.3)	(0.2)	(0.4)	(0.5)	(0.4)	(0.0)	(0.5)	(0.2)	(0.2)	(0.2)
Land Converted to Grazed Land	(0.2)	(0.7)	(1.7)	(1.9)	(1.7)	(1.5)	(1.3)	(1.2)	(1.3)	(1.3)	(1.3)
Pennsylvania	**(0.4)**	**(0.7)**	**(1.1)**	**(1.2)**	**(0.9)**	**(0.9)**	**(0.8)**	**(0.8)**	**(0.8)**	**(0.8)**	**(0.8)**
Grazed Lands Remaining Grazed	(0.2)	(0.1)	(0.1)	(0.2)	0.0	0.1	(0.1)	0.0	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.2)	(0.5)	(1.0)	(1.1)	(0.9)	(0.9)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Rhode Island	**(0.0)**	**(0.0)**	**(0.0)**	**0.0**	**(0.0)**	**(0.0)**	**0.0**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0	0.0	(0.0)	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
South Carolina	**(0.4)**	**(0.3)**	**(0.5)**	**(0.4)**	**(0.3)**	**(0.4)**	**(0.4)**	**(0.4)**	**(0.3)**	**(0.3)**	**(0.3)**
Grazed Lands Remaining Grazed	(0.1)	(0.0)	(0.1)	0.0	0.0	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.2)	(0.3)	(0.4)	(0.4)	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)

South Dakota	**(0.7)**	**(0.2)**	**(2.3)**	**(0.5)**	**0.1**	**(0.4)**	**0.0**	**(0.9)**	**(0.7)**	**(0.7)**	**(0.7)**
Grazed Lands Remaining Grazed	(0.3)	0.1	(1.7)	(0.0)	0.5	0.1	0.6	(0.4)	(0.2)	(0.2)	(0.2)
Land Converted to Grazed Land	(0.3)	(0.3)	(0.6)	(0.4)	(0.4)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Tennessee	**(1.4)**	**(1.5)**	**(1.3)**	**(1.2)**	**(0.9)**	**(0.5)**	**(0.7)**	**(0.6)**	**(0.5)**	**(0.5)**	**(0.5)**
Grazed Lands Remaining Grazed	(0.4)	(0.4)	(0.3)	(0.2)	(0.3)	(0.0)	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)
Land Converted to Grazed Land	(0.9)	(1.0)	(1.0)	(0.9)	(0.7)	(0.4)	(0.5)	(0.4)	(0.4)	(0.4)	(0.4)
Texas	**(1.5)**	**(1.2)**	**(5.8)**	**(3.4)**	**(3.0)**	**(3.3)**	**(1.7)**	**(1.1)**	**(2.2)**	**(2.2)**	**(2.1)**
Grazed Lands Remaining Grazed	1.1	2.1	(0.9)	1.5	1.8	0.9	2.2	2.7	1.5	1.6	1.6
Land Converted to Grazed Land	(2.6)	(3.3)	(4.9)	(4.9)	(4.8)	(4.3)	(3.9)	(3.8)	(3.7)	(3.7)	(3.7)
Utah	**0.0**	**(1.1)**	**(4.7)**	**(3.1)**	**(5.5)**	**(5.0)**	**(3.4)**	**(3.7)**	**(4.0)**	**(4.0)**	**(4.0)**
Grazed Lands Remaining Grazed	0.1	0.5	(0.0)	2.1	(0.1)	(0.0)	0.6	0.0	0.2	0.2	0.2
Land Converted to Grazed Land	(0.1)	(1.6)	(4.7)	(5.3)	(5.3)	(5.0)	(4.1)	(3.8)	(4.2)	(4.2)	(4.2)
Vermont	**(0.1)**	**(0.1)**	**(0.1)**	**(0.0)**	**(0.0)**	**0.0**	**(0.0)**	**0.0**	**(0.0)**	**(0.0)**	**(0.0)**
Grazed Lands Remaining Grazed	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0
Land Converted to Grazed Land	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Virginia	**(1.1)**	**(0.8)**	**(0.9)**	**(0.9)**	**(0.7)**	**(0.4)**	**(0.5)**	**(0.4)**	**(0.4)**	**(0.4)**	**(0.4)**
Grazed Lands Remaining Grazed	(0.4)	(0.2)	(0.3)	(0.3)	(0.2)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.7)	(0.6)	(0.6)	(0.6)	(0.5)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
Washington	**(0.3)**	**(0.2)**	**(0.5)**	**(0.4)**	**(0.3)**	**(0.4)**	**(0.1)**	**0.0**	**(0.3)**	**(0.3)**	**(0.3)**
Grazed Lands Remaining Grazed	(0.0)	0.1	0.0	0.1	0.3	0.2	0.3	0.3	0.1	0.1	0.2
Land Converted to Grazed Land	(0.2)	(0.3)	(0.6)	(0.5)	(0.6)	(0.5)	(0.4)	(0.3)	(0.4)	(0.4)	(0.4)
West Virginia	**(0.5)**	**(0.6)**	**(0.6)**	**(0.6)**	**(0.4)**	**(0.3)**	**(0.4)**	**(0.3)**	**(0.3)**	**(0.3)**	**(0.3)**
Grazed Lands Remaining Grazed	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)
Land Converted to Grazed Land	(0.4)	(0.5)	(0.5)	(0.5)	(0.4)	(0.3)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)
Wisconsin	**(0.2)**	**(0.2)**	**(0.5)**	**(0.3)**	**0.3**	**0.1**	**0.3**	**0.2**	**0.1**	**0.1**	**0.1**
Grazed Lands Remaining Grazed	0.2	0.2	0.1	0.3	0.5	0.3	0.5	0.4	0.2	0.2	0.3
Land Converted to Grazed Land	(0.3)	(0.4)	(0.6)	(0.6)	(0.2)	(0.2)	(0.2)	(0.1)	(0.2)	(0.2)	(0.2)
Wyoming	**0.2**	**(0.5)**	**(1.3)**	**(1.8)**	**(1.7)**	**(0.8)**	**(0.5)**	**0.0**	**(0.9)**	**(0.9)**	**(0.8)**
Grazed Lands Remaining Grazed	0.3	0.3	0.1	(0.3)	(0.0)	0.6	0.8	1.0	0.3	0.3	0.4
Land Converted to Grazed Land	(0.1)	(0.8)	(1.4)	(1.5)	(1.7)	(1.4)	(1.3)	(1.0)	(1.2)	(1.2)	(1.2)

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

[1] Estimate includes Federal and non-Federal Grasslands. SOC change due to Biosolids Additions were excluded.

Appendix Table A-27 State-Level Estimates of Total Grassland Area, Grassland Area Included in Tier 3 Method, and Percent of Total Grassland Included in Tier 3 Method, 1990, 1995, 2000, 2005, 2010, 2013–2015

		1990	1995	2000	2005	2010	2013	2014	2015
State	Area (Million ha)				*MMT CO_2 eq.*				
Alabama	Grassland Area	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4
	Tier 3 Area	0.9	0.9	1.0	1.2	1.2	1.2	1.2	1.2
	Tier 3 Proportion of Land Base (%)	65.7	69.5	75.7	82.1	85.8	86.2	86.0	86.2
Arizona	Grassland Area	22.7	22.5	22.2	22.1	22.1	22.1	22.1	22.1
	Tier 3 Area	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.0
	Tier 3 Proportion of Land Base (%)	44.4	44.7	45.5	45.7	45.6	45.5	45.5	45.5
Arkansas	Grassland Area	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9
	Tier 3 Area	1.2	1.3	1.4	1.4	1.4	1.4	1.4	1.4
	Tier 3 Proportion of Land Base (%)	65.6	69.4	72.8	73.9	75.1	74.5	73.8	74.0
California	Grassland Area	18.6	18.6	18.6	18.7	18.9	18.8	18.8	18.8
	Tier 3 Area	7.0	7.1	7.3	7.3	7.4	7.4	7.3	7.3
	Tier 3 Proportion of Land Base (%)	37.4	38.2	39.1	39.1	39.2	39.0	38.8	38.6
Colorado	Grassland Area	13.9	13.9	14.0	14.0	14.0	14.0	14.0	14.0
	Tier 3 Area	9.3	9.3	9.4	9.4	9.4	9.4	9.4	9.4
	Tier 3 Proportion of Land Base (%)	67.0	67.0	67.1	67.1	67.3	67.3	67.5	67.5
Connecticut	Grassland Area	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0

	Tier 3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	70.9	72.2	77.8	80.1	81.3	77.1	77.0	76.5
Delaware	Grassland Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	39.6	48.6	53.2	77.3	71.0	83.2	83.6	86.2
Florida	Grassland Area	2.7	2.7	2.6	2.5	2.6	2.6	2.6	2.6
	Tier 3 Area	1.7	1.8	1.9	2.0	2.0	2.0	2.0	2.0
	Tier 3 Proportion of Land Base (%)	60.3	64.7	71.0	76.9	77.9	78.5	78.5	78.4
Georgia	Grassland Area	0.9	0.9	1.0	1.1	1.1	1.0	1.0	1.0
	Tier 3 Area	0.6	0.7	0.7	0.8	0.9	0.8	0.8	0.8
	Tier 3 Proportion of Land Base (%)	63.0	69.8	73.1	77.2	79.9	79.6	78.7	78.8
Hawaii	Grassland Area	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
	Tier 3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	Grassland Area	10.0	9.9	10.0	9.9	9.7	9.7	9.7	9.6
	Tier 3 Area	2.8	2.7	2.8	2.8	2.8	2.8	2.8	2.8
	Tier 3 Proportion of Land Base (%)	27.6	27.6	28.0	28.5	28.9	29.3	29.3	29.3
Illinois	Grassland Area	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8
	Tier 3 Area	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Tier 3 Proportion of Land Base (%)	76.3	79.1	82.9	85.1	87.7	89.8	90.9	91.5
Indiana	Grassland Area	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
	Tier 3 Area	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5
	Tier 3 Proportion of Land Base (%)	76.1	77.5	78.5	81.5	84.0	85.0	85.4	86.4
Iowa	Grassland Area	1.3	1.2	1.3	1.3	1.3	1.2	1.2	1.3
	Tier 3 Area	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3
	Tier 3 Proportion of Land Base (%)	85.1	87.6	90.7	93.0	94.5	95.0	95.2	95.7
Kansas	Grassland Area	7.1	7.1	7.2	7.3	7.5	7.5	7.5	7.5
	Tier 3 Area	6.8	6.8	6.9	7.0	7.3	7.3	7.3	7.3
	Tier 3 Proportion of Land Base (%)	95.3	95.8	96.1	96.6	97.0	97.3	97.3	97.4
Kentucky	Grassland Area	2.1	2.1	2.0	1.9	1.9	1.9	1.9	1.9
	Tier 3 Area	1.6	1.7	1.7	1.6	1.7	1.6	1.6	1.6
	Tier 3 Proportion of Land Base (%)	77.0	79.0	83.2	83.9	85.3	85.7	85.7	86.2
Louisiana	Grassland Area	1.1	1.2	1.2	1.2	1.1	1.1	1.1	1.1
	Tier 3 Area	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.0
	Tier 3 Proportion of Land Base (%)	73.0	75.6	78.7	81.2	84.6	88.1	88.6	88.9
Maine	Grassland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier 3 Area	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier 3 Proportion of Land Base (%)	52.5	65.4	71.7	82.9	89.3	89.3	89.6	89.8
Maryland	Grassland Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier 3 Area	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
	Tier 3 Proportion of Land Base (%)	57.3	62.9	68.3	75.3	81.1	82.2	81.8	82.6
Massachusetts	Grassland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier 3 Area	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	65.2	71.0	81.7	77.9	78.8	72.8	69.4	69.4
Michigan	Grassland Area	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9
	Tier 3 Area	0.5	0.5	0.6	0.8	0.7	0.7	0.7	0.7
	Tier 3 Proportion of Land Base (%)	53.3	60.0	70.2	77.0	79.6	81.2	81.4	82.2
Minnesota	Grassland Area	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9
	Tier 3 Area	1.2	1.3	1.4	1.4	1.5	1.5	1.5	1.5
	Tier 3 Proportion of Land Base (%)	67.8	70.0	73.7	75.6	76.9	77.8	78.1	78.5
Mississippi	Grassland Area	0.9	0.9	1.0	1.1	1.1	1.1	1.1	1.1
	Tier 3 Area	0.5	0.6	0.7	0.8	0.9	0.9	0.9	0.9
	Tier 3 Proportion of Land Base (%)	56.1	60.8	68.6	75.6	80.6	83.7	84.5	84.8
Missouri	Grassland Area	4.3	4.1	4.1	4.1	4.0	3.8	3.8	3.8

	Tier 3 Area	3.1	3.1	3.2	3.2	3.2	3.0	3.0	3.0
	Tier 3 Proportion of Land Base (%)	73.1	75.0	78.3	78.9	79.0	78.8	78.4	78.6
Montana	Grassland Area	19.9	19.7	19.7	19.6	19.6	19.7	19.7	19.7
	Tier 3 Area	15.3	15.2	15.3	15.3	15.4	15.5	15.5	15.6
	Tier 3 Proportion of Land Base (%)	77.0	77.3	77.6	78.1	78.3	78.6	78.7	78.8
Nebraska	Grassland Area	10.0	9.9	10.0	10.0	10.0	10.0	10.0	10.0
	Tier 3 Area	9.7	9.7	9.7	9.8	9.8	9.8	9.8	9.8
	Tier 3 Proportion of Land Base (%)	97.3	97.3	97.6	97.6	97.7	97.8	97.8	97.9
Nevada	Grassland Area	24.5	24.3	24.1	24.0	23.9	23.8	23.8	23.8
	Tier 3 Area	2.8	2.8	2.9	2.9	2.9	2.9	2.9	2.9
	Tier 3 Proportion of Land Base (%)	11.5	11.7	11.8	11.9	12.1	12.1	12.1	12.1
New Hampshire	Grassland Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	69.8	75.8	81.9	79.7	85.1	83.2	82.3	83.0
New Jersey	Grassland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier 3 Area	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0
	Tier 3 Proportion of Land Base (%)	54.0	64.1	69.6	71.9	72.8	74.2	74.4	76.3
New Mexico	Grassland Area	23.2	23.3	23.4	23.4	23.5	23.6	23.6	23.6
	Tier 3 Area	14.4	14.5	14.6	14.6	14.7	14.7	14.7	14.7
	Tier 3 Proportion of Land Base (%)	62.1	62.3	62.4	62.4	62.4	62.4	62.4	62.4
New York	Grassland Area	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.0
	Tier 3 Area	0.5	0.6	0.7	0.8	0.9	0.9	0.9	0.9
	Tier 3 Proportion of Land Base (%)	63.9	71.5	77.5	81.5	86.3	88.1	89.1	89.8
North Carolina	Grassland Area	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.9
	Tier 3 Area	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Tier 3 Proportion of Land Base (%)	69.3	72.7	74.9	78.6	81.7	82.8	82.2	80.7
North Dakota	Grassland Area	5.4	5.3	5.4	5.5	5.6	5.7	5.8	5.8
	Tier 3 Area	4.6	4.5	4.6	4.7	4.8	5.0	5.0	5.0
	Tier 3 Proportion of Land Base (%)	84.7	85.2	85.7	86.2	86.1	86.3	86.5	86.8
Ohio	Grassland Area	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
	Tier 3 Area	0.4	0.5	0.6	0.6	0.7	0.7	0.6	0.6
	Tier 3 Proportion of Land Base (%)	65.7	71.3	77.4	79.3	81.1	83.4	83.0	83.5
Oklahoma	Grassland Area	7.1	7.3	7.6	7.7	7.8	7.9	8.0	8.0
	Tier 3 Area	6.5	6.7	7.1	7.2	7.4	7.6	7.6	7.7
	Tier 3 Proportion of Land Base (%)	91.1	92.3	93.9	94.3	95.0	95.5	95.7	96.0
Oregon	Grassland Area	9.7	9.8	10.0	10.0	10.1	10.1	10.1	10.1
	Tier 3 Area	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.2
	Tier 3 Proportion of Land Base (%)	32.0	31.9	32.0	31.8	32.0	31.8	31.8	31.6
Pennsylvania	Grassland Area	0.7	0.6	0.8	0.8	0.8	0.8	0.8	0.8
	Tier 3 Area	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6
	Tier 3 Proportion of Land Base (%)	60.8	65.2	70.2	76.0	81.1	81.5	82.1	82.3
Rhode Island	Grassland Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier 3 Proportion of Land Base (%)	57.4	65.4	73.3	72.5	71.8	73.6	73.9	76.4
South Carolina	Grassland Area	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	Tier 3 Area	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4
	Tier 3 Proportion of Land Base (%)	66.9	71.2	74.6	80.7	82.8	84.7	86.6	87.4
South Dakota	Grassland Area	10.5	10.4	10.4	10.3	10.3	10.4	10.3	10.3
	Tier 3 Area	9.7	9.5	9.6	9.6	9.6	9.6	9.6	9.5
	Tier 3 Proportion of Land Base (%)	92.0	92.2	92.3	92.4	92.6	92.5	92.5	92.5
Tennessee	Grassland Area	1.9	1.9	1.9	1.9	1.8	1.7	1.7	1.7
	Tier 3 Area	1.5	1.6	1.6	1.6	1.6	1.6	1.5	1.5
	Tier 3 Proportion of Land Base (%)	76.2	80.8	85.5	86.9	88.9	90.0	89.6	89.8

Texas	Grassland Area	37.8	37.5	37.5	37.3	37.2	36.8	36.7	36.6
	Tier 3 Area	29.1	29.3	29.7	29.8	29.9	29.7	29.6	29.6
	Tier 3 Proportion of Land Base (%)	77.2	78.1	79.1	79.8	80.3	80.7	80.7	80.8
Utah	Grassland Area	13.5	13.6	13.8	13.7	13.6	13.5	13.5	13.5
	Tier 3 Area	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	Tier 3 Proportion of Land Base (%)	24.1	24.3	23.8	24.2	24.2	24.2	24.2	24.3
Vermont	Grassland Area	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
	Tier 3 Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier 3 Proportion of Land Base (%)	66.9	74.0	84.9	89.1	89.6	90.0	90.0	90.0
Virginia	Grassland Area	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2
	Tier 3 Area	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.0
	Tier 3 Proportion of Land Base (%)	79.0	83.4	86.8	88.0	88.5	89.4	88.8	89.3
Washington	Grassland Area	3.7	3.6	3.6	3.6	3.7	3.7	3.7	3.6
	Tier 3 Area	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3
	Tier 3 Proportion of Land Base (%)	59.3	60.6	61.9	62.7	63.0	63.2	63.2	63.0
West Virginia	Grassland Area	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
	Tier 3 Area	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5
	Tier 3 Proportion of Land Base (%)	59.2	65.8	70.9	77.3	79.8	82.4	82.6	82.6
Wisconsin	Grassland Area	1.1	1.1	1.2	1.3	1.2	1.2	1.2	1.2
	Tier 3 Area	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0
	Tier 3 Proportion of Land Base (%)	70.9	72.5	77.8	81.1	82.7	84.2	84.2	84.3
Wyoming	Grassland Area	18.9	18.9	18.9	19.4	19.3	19.3	19.3	19.3
	Tier 3 Area	10.2	10.2	10.2	10.4	10.4	10.4	10.4	10.4
	Tier 3 Proportion of Land Base (%)	54.0	54.0	54.0	53.8	53.9	54.0	54.1	54.2

Note: M ha is million hectares.

Chapter 3: Cropland Agriculture

Data from Chapter 3 can be downloaded from:
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3.1 Summary of U.S. Greenhouse Gas Emissions From Cropland Agriculture

Based on IPCC Tier 1 (default emission factors) and Tier 3 (DayCent model simulations) methods, cropland agriculture emitted approximately 297 MMT CO_2 eq. of greenhouse gases (GHG) in 2018 (Table 3-1). Cropland agriculture is responsible for almost half (48 percent) of all emissions from the agricultural sector (EPA 2020). Nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) emissions from cropland soils totaled 239, 45, and 14 MMT CO_2 eq. in 2018. However, that amount was partly offset by a storage, or carbon sequestration, of 46 MMT CO_2 eq. in cropland mineral soils during 2018. When carbon sequestration is considered, net emissions of GHG from cropland agriculture amount to approximately 251 MMT CO_2 eq. The 95-percent confidence interval for net emissions in 2018 is between 117 and 384 MMT CO_2 eq. (Table 3-1).

Annual fluctuations in CO_2 emissions and removals are primarily a result of changes in land use and management and variability in weather patterns. In 2018, net emissions from cropland agriculture were about 11 percent higher than the baseline year (1990), mainly due to an increase in N_2O emissions associated with increased crop production and a reduction in the CO_2 sink associated with cropland mineral soils. Greenhouse gas emissions from agricultural soils fluctuated between 1990 and 2018, with CH_4 and N_2O reaching their highest levels in 2015 and 2014 respectively (Table 3-2). Net CO_2 flux showed substantial interannual variability, mainly due to fluctuations in the size of the mineral soil CO_2 sink.

Greenhouse gas emissions from agricultural soils, primarily N_2O, were responsible for the majority of total emissions (80 percent), while CH_4 and N_2O from residue burning and rice cultivation caused less than 1 percent of emissions in 2018 (Tables 3-1, 3-2). Soil CO_2 emissions from cultivation of organic soils (12 percent), from liming (1 percent), and from urea fertilization (2 percent) are the remaining sources. Nitrous oxide emissions from soils are the largest anthropogenic source in the United States because of nitrogen management practices. Large amounts of nitrogen are added to crops from fertilizer amendments and legume cropping, which stimulate N_2O production. Organic nitrogen, mainly from livestock manure amendments, and nitrogen

Table 3-1 Estimates and Uncertainties for Cropland Greenhouse Gas Emissions, 2018

	GHG Emissions	Lower Bound	Upper Bound
Source		*MMT CO_2 eq.*	
N_2O	**239**	**159**	**359**
Soils Direct	196	131	294
Soils Indirect[1]	43	11	159
Residue Burning	0.2	0.1	0.2
CH_4	**14**	**8**	**20**
Residue Burning	0.4	0.3	0.5
Rice Cultivation	13	9	22
CO_2	**(2)**	**(93)**	**89**
Mineral Soils	(46)	(135)	42
Organic Soils	37	17	56
Liming of Soils	3	(0)	6
Urea	5	3	5
Total Emissions	**297**	**198**	**396**
Net Emissions[3]	**251**	**117**	**384**

Note: Parentheses indicate a net sequestration. MMT CO_2 eq. is million metric tons carbon dioxide equivalent. CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide.
[1] Indirect soil N_2O emissions account for volatilization and leaching/runoff losses of N.
[2] Includes sources and sinks

Table 3-2 Summary of Greenhouse Gas Emissions From Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Source	*MMT CO_2 eq.*										
N_2O	**220.3**	**217.9**	**207.4**	**216.0**	**222.8**	**236.2**	**245.7**	**243.3**	**231.0**	**229.3**	**238.9**
Soils Direct	185.9	183.7	177.1	184.1	186.3	198.0	207.6	200.2	191.6	191.3	196.0
Soils Indirect[1]	34.2	34.1	30.2	31.8	36.3	38.1	37.9	43.0	39.2	37.8	42.8
Residue Burning	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CH_4	**16.3**	**16.8**	**19.3**	**18.4**	**19.3**	**14.2**	**15.8**	**16.6**	**13.9**	**13.2**	**13.7**
Residue Burning	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Rice Cultivation	16.0	16.5	19.0	18.0	18.9	13.8	15.4	16.2	13.5	12.8	13.3
CO_2	**(10.5)**	**5.8**	**(7.3)**	**(15.9)**	**(2.2)**	**(0.5)**	**3.5**	**3.7**	**(8.7)**	**(7.6)**	**(2.0)**
Mineral Soils	(55.8)	(39.6)	(47.0)	(61.1)	(46.5)	(43.5)	(40.3)	(39.9)	(51.0)	(51.7)	(46.3)
Organic Soils	38.6	38.6	32.5	37.7	36.1	35.3	36.3	35.8	35.2	36.5	36.5
Liming of Soils[2]	4.7	4.4	4.3	4.3	4.8	3.9	3.6	3.7	3.1	3.1	3.1
Urea[2]	2.0	2.4	2.9	3.1	3.4	3.8	3.9	4.1	4.0	4.5	4.6
Total Emissions	**281.9**	**280.1**	**266.4**	**279.6**	**286.4**	**293.4**	**305.3**	**303.5**	**287.2**	**286.5**	**296.9**
Net Emissions[3]	**226.1**	**240.5**	**219.4**	**218.5**	**239.9**	**249.9**	**265.0**	**263.6**	**236.2**	**234.9**	**250.6**

Note: Parentheses indicate a net sequestration. MMT CO_2 eq. is million metric tons carbon dioxide equivalent. CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide.
[1] Indirect soil N_2O emissions account for both volatilization and leaching/runoff.
[2] Include CO2 emissions from urea fertilization and liming applied to all farmland.
[3] Includes sources and sinks.

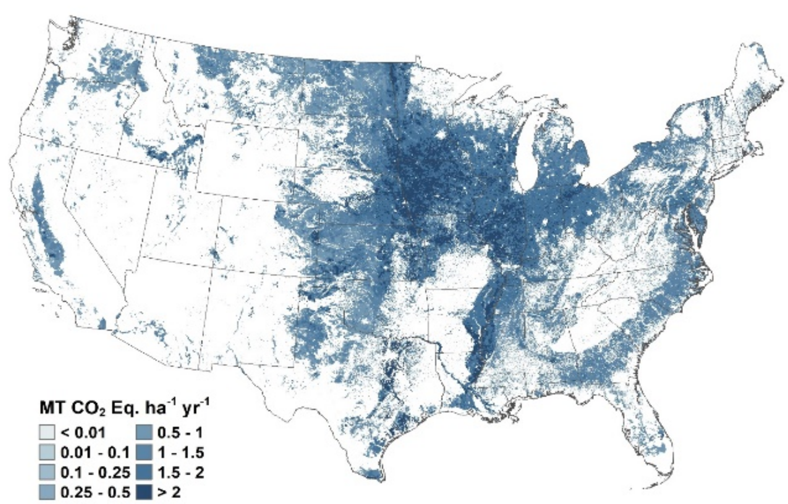
released from decomposition of origin matter in drained organic soils also contribute to N_2O emissions. Emissions from residue burning are minor because only ~1 percent of crop residue is burned in the United States (EPA 2020). Cropland mineral soils in the United States are a net CO_2 sink for various reasons, including increased carbon inputs from improved crop varieties and residues, as well as other practices that reduce the decomposition of soil organic matter and subsequent losses of carbon from the soil. For example, adoption of conservation tillage, which began to increase in the 1980s, leads to an increase in soil carbon due to lower rates of decomposition of soil organic matter with less soil disturbance.

Lands that are used for perennial grass and legume hay production, as well as increased manure amendments contribute more carbon to the soil and lead to larger amounts of carbon in soils. Idle cropland enrolled in the Conservation Reserve Program (CRP) leads to larger amounts of soil carbon storage because there can be more inputs of carbon to the soil and less decomposition of soil organic matter with reduced soil disturbance compared to cultivated cropland. The magnitude of the mineral soil carbon stock varies annually in response to weather and land conversion such as to and from forest land and grazing land uses.

Nitrous oxide emissions are largest in regions with extensive row crop production (Map 3-1). More than 50 percent of the land area in some Midwestern Corn Belt States is used intensively for row crop production. Row crops such as corn, soybeans, and sorghum make up close to 36 percent of total cropland (Figure 3-1a, Figure 3-1b, Table 3-3) and have the highest N_2O emissions, followed by irrigated crops, which are more common in semi-arid regions, in addition to small grain crops such as wheat, barley and rye, cropland with fallow in rotations, other cropland, and grass plus legume hay (Table 3-4). Like Figure 3-1a, Map 3-1 and Table 3-3 only include areas and emissions from cropland that are included in the Tier 3 analysis, which covers ~80–83 percent of total cropland across the time series from 1990 to 2015.

Map 3-1 Total Nitrous Oxide Emissions (Direct and Indirect) From Cropland, 2015

(MT CO_2 eq. ha^{-1} yr^{-1} is metric tons carbon dioxide equivalent per hectare per year.)



Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method.

The years 2016–2018 are not included in these figures and maps because the Tier 3 analysis relies on the National Resources Inventory (NRI) (USDA 2018a) for activity data and 2015 is the most recent year data are available. As explained in 3.3.1, a data splicing method was used to estimate emissions for subsequent years, but this introduces additional uncertainty. Appendix Table B-7 provides State-level land area estimates for major crop management systems that are presented in Table 3-3 and Figure 3-1a.

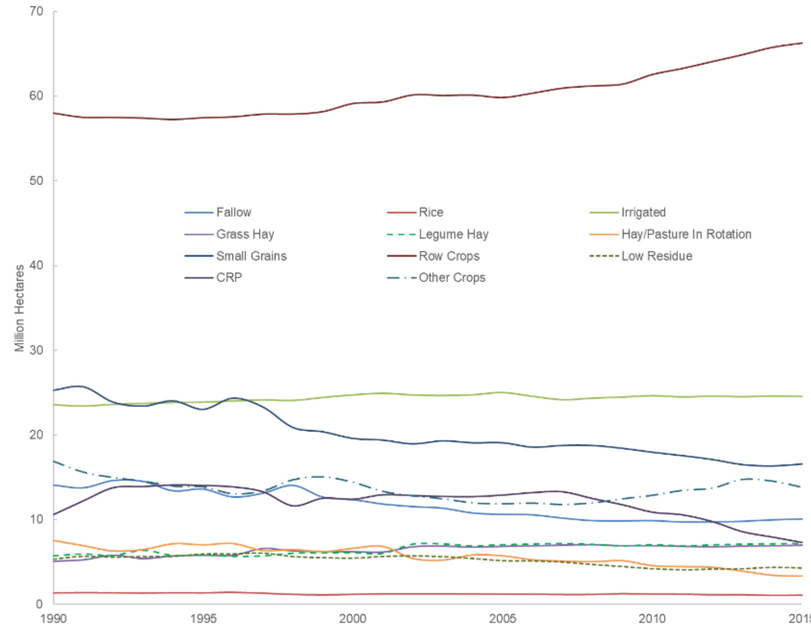


Figure 3-1a Planted Area by Management System in the United States, 1990–2015
Note: CRP is USDA Conservation Reserve Program

Cropland agriculture results in GHG emissions from multiple sources, with the magnitude of emissions partly determined by land management practices. Application of synthetic and organic fertilizers, cultivation of N-fixing crops and rice, cultivation and management of soils, and field burning of crop residues lead to emissions of N_2O, CH_4, and CO_2. However, agricultural soils can also mitigate GHG emissions through the biological uptake of CO_2 related to crop production and subsequent storage in soils, resulting in CO_2 removals from the atmosphere. This chapter covers both GHG emissions from cropland agriculture and biological uptake of CO_2 that can lead to increases in soil organic carbon for agricultural lands. National estimates of these sources, published in the U.S. GHG Inventory, are reported in this section, and State-level emissions estimates are provided in the appendix tables. Sources and sinks of N_2O, CH_4, and CO_2 and the mechanisms that control fluxes are discussed in detail. Methodologies used to estimate emissions are summarized and mitigation opportunities are discussed and quantified where possible. The methodologies used here are similar to those reported in the fourth edition of the USDA GHG report (USDA 2016), with some improvements in models that are used to estimate emissions, and associated input activity data that provide historical information on cropland management practices.

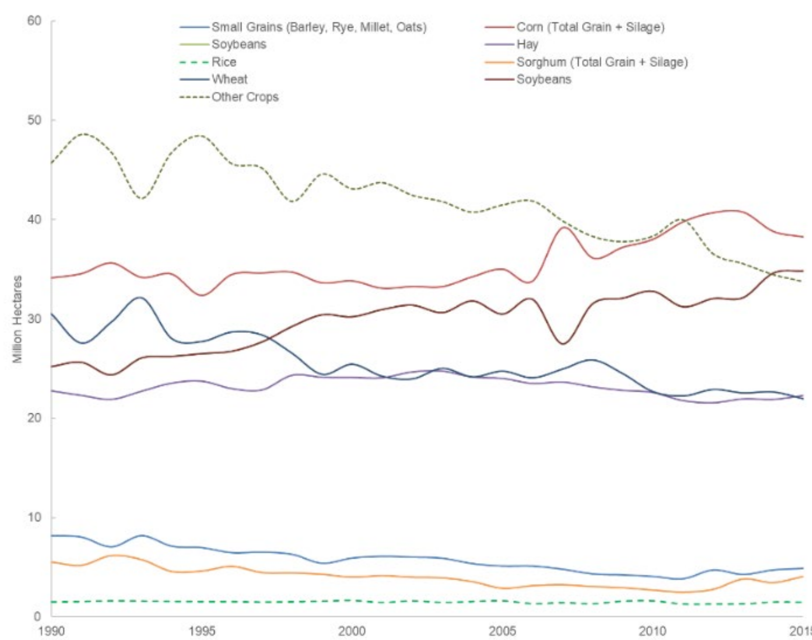


Figure 3-1b Planted Area by Crop Type in the United States, 1990–2015

Emissions are partitioned by crop management systems and reported at the national and State levels.

Emissions and particularly soil organic carbon stock changes are influenced by management systems that are practiced over several years or longer, and therefore the changes in a single year reflect the past management history. For example, wheat might be growing during a particular year, but the emissions for that year are partly (and sometimes largely) due to management in a previous year(s). Because of the influence of prior management, emissions were partitioned into 11 major crop management systems

(Table 3-3, Figure 3-1a). The classification was designed to be mutually exclusive so a field, or management unit, could only be classified into one management system in a year of the inventory. For example, land area used predominately for production of row crops that was also irrigated would appear in the irrigated category and not be included in the row crops category. If the classification was not mutually exclusive, then there would be double accounting of emissions to the extent that management units were classified into more than one category.

The classification for a single year was based on the most recent 5 years of history. Management system categories were defined using a general majority rule. For example, if a land area was fallow at least 3 out of 5 years, then it was classified as fallow, if land was in rice production at least 3 out of 5 years, it was classified as rice, and so on. Also, emissions for management systems were only estimated with the Tier 3 method (See Section 3.3.1), approximately 80–83 percent of the land base as noted previously, because the Tier 3 method included sufficient information to quantify emissions for the individual management units. Emissions for other cropland areas were estimated in aggregate using the simple Tier 1 or 2 methods. It is anticipated that the Tier 3 methods will be applied to a larger proportion of the land base in the future.

3.2 Sources and Sinks of Greenhouse Gas Emissions in Cropland Agriculture

3.2.1 Cropland Soils

Agricultural soils act as both a source of GHGs and a mechanism to remove CO_2 from the atmosphere, i.e., CO_2 sink. Nitrous oxide, CH_4, and CO_2 emissions and sinks are a function of underlying biochemical processes. Nitrous oxide is produced as an intermediate byproduct during nitrification and denitrification in soils (Firestone & Davidson 1989). In nitrification, soil micro-organisms ("microbes") convert ammonium (NH_4) to nitrate (NO_3) through aerobic oxidation (IPCC 2006). In denitrification, microbes convert nitrate to nitrogen oxides (NO_x) and nitrogen gas (N_2) by anaerobic reduction. During nitrification and denitrification, N_2O is created as a byproduct, which can diffuse from the soil and enter the earth's atmosphere (IPCC 2006). Cropland soil amendments and other practices that enhance nitrogen levels drive the production of N_2O by providing additional substrate for nitrification and denitrification. Synthetic fertilizer, livestock manure, cultivation of N-fixing crops, and incorporation of crop residues all add various forms of N to soils. In addition, cultivation, particularly of soils high in organic matter (i.e., histosols), enhances mineralization of nitrogen-rich organic matter, making more nitrogen available for nitrification and denitrification (IPCC 2006). Compared to soil N_2O emissions, other GHG sources from croplands are relatively small. Methane gas is produced and emitted primarily from rice paddies. This, however, is responsible for only for a small portion of total emissions from cropland soils in the United States due to the relatively minor amount of the land area with paddy rice. Crop residue burning is also a minor source due to the small proportion of residues burned in the United States.

Nitrogen can be converted to N_2O and emitted directly from agricultural fields (direct emissions), or it can be transported from the field in another form of nitrogen and then converted to N_2O elsewhere (indirect emissions). A major source of indirect N_2O emissions is from nitrate that either leaches into the groundwater or runs off the soil surface and then is converted to N_2O via aquatic denitrification (Del Grosso et al. 2006). A second source of indirect N_2O emissions comes from nitrogen that is volatilized to the atmosphere as ammonia (NH_3) or NO_x then is

Table 3-3 Area by Cropland Management Systems, 1990, 1995, 2000, 2005, 2010, 2013–2015

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*Million Hectares*							
Fallow	12.6	12.3	11.3	9.9	9.3	9.3	9.5	9.6
Rice	1.2	1.2	1.0	1.0	1.1	1.0	0.9	1.0
Irrigated	15.7	16.0	16.9	17.3	17.1	17.0	17.1	17.1
Grass Hay	4.2	5.1	5.5	6.2	6.3	6.3	6.3	6.4
Legume Hay	4.9	5.1	5.6	6.5	6.6	6.6	6.6	6.7
Hay/Pasture In Rotation	6.5	6.1	5.8	5.1	4.1	3.5	3.1	3.0
Small Grains	21.5	19.3	16.1	15.8	14.8	13.7	13.6	13.8
Row Crops	51.3	51.9	54.3	55.0	57.5	59.7	60.5	60.9
Low Residue	4.3	4.7	4.5	4.2	3.3	3.4	3.5	3.4
USDA Conservation Reserve Program	9.5	12.5	11.3	12.0	10.3	8.3	7.7	7.1
Other Crops	8.5	6.2	6.7	4.6	5.5	6.9	6.7	6.2
Total Cropland	**140.1**	**140.4**	**139.1**	**137.5**	**136.0**	**135.7**	**135.6**	**135.2**

deposited back onto soils and converted to N_2O (Del Grosso et al. 2006).

Cropland soils can be a source or sink of CO_2. Net CO_2 flux is related to changes soil organic carbon (SOC) stocks (IPCC 2006). Changes in SOC content are controlled by the balance between C inputs (e.g., atmospheric CO_2 fixed as carbon in plants through photosynthesis) and losses from plant (autotrophic) respiration and decomposition of soil organic matter and plant litter (IPCC 2006). The net balance of CO_2 uptake and loss in soils is driven in part by biological processes, which are affected by soil characteristics and climate. In addition, land use and management can affect the net balance of CO_2 through modifying inputs and rates of decomposition (IPCC 2006). Changes in agricultural practices such as vegetation clearing, water drainage, tillage, crop selection, irrigation, grazing, crop residue management, fertilization, and flooding can modify both organic matter inputs and decomposition and thereby result in a net flux of CO_2 to or from soils.

Most agricultural soils contain comparatively low amounts of organic carbon as a percentage of total soil mass, typically in the range of 1 to 6 percent organic C by weight and are classified as mineral soils (USDA 1999). However, on an area basis, this amount of carbon typically exceeds that stored in vegetation of most ecosystems. Historically, conversion of native ecosystems to agricultural uses resulted in large soil carbon losses, as much as 30 to 50 percent or more of the C present in the native condition (Haas et al. 1957, Schlesinger 1986, Guo & Gifford 2002, Lal 2004, Ogle et al. 2005). Presently, after many decades of cultivation in most areas of the United States, soils have low carbon levels or are increasing their organic matter levels as a result of increasing crop productivity (providing more residues), less intensive tillage, and other improvements in agricultural management practices (Paustian et al. 1997, 2016, Allmaras et al. 2000, Follett 2001). Changes in land use or management practices that result in increased organic inputs or decreased oxidation of organic matter (e.g., taking cropland out of production, improved crop rotations, cover crops, application of organic amendments and manure, and reduction or elimination of tillage) usually result in a net accumulation of SOC until a new equilibrium is achieved.

Cultivated organic soils, also referred to as histosols, contain more than 12 to 20 percent organic matter by weight and constitute a special case (USDA 1999, Brady & Weil 1999). Organic soils form as a result of water-logged conditions, in which decomposition of plant residue is inhibited due to anaerobic conditions with low oxygen levels. When organic soils are drained and cultivated, the rate of decomposition, and hence CO_2 emissions, is greatly accelerated with aerobic conditions and higher oxygen levels. In addition to CO_2, decomposing organic soils also release nitrogen which contributes to N_2O emissions Due to the depth and richness of the organic layers, carbon loss from cultivated organic soils can continue over long periods of time.

In addition, lime is often added to mineral and organic agricultural soils to reduce acidic conditions. Lime contains carbonate compounds (e.g., limestone and dolomite) that when added to soils release CO_2 through the bicarbonate equilibrium reaction to increase alkalinity (IPCC 2006). Similarly, urea fertilizers will release CO_2 as hydrolysis of urea occurs in the soil (IPCC 2006).

3.2.2 Rice Cultivation

Rice is usually cultivated on flooded fields and is almost always grown in flooded fields in the United States (EPA 2020). This water regime causes CH_4 emissions as a result of waterlogged soils restricting oxygen diffusion and creating conditions for anaerobic decomposition of organic matter, facilitated by CH_4-emitting, methanogenic bacteria (IPCC 2006, Le Mer & Roger 2001). Methane from paddy rice fields reaches the atmosphere in three ways: bubbling up through the soil, diffusion losses from the water surface, and diffusion through the vascular elements of plants (IPCC 2006). Diffusion through plants is considered the primary pathway, with diffusion losses from surface water being the least important process (IPCC 2006). Soil composition, texture, and temperature are important variables affecting CH_4 emissions from rice cultivation, as are the availability of carbon substrate and other nutrients, soil pH, and partial pressure of CH_4 (IPCC 2006). Since paddy rice acreage in the United States is relatively small compared to other crops, CH_4 emissions from rice cultivation are a relatively minor source of emissions compared to other domestic cropland agriculture sources (Table 3-1) (EPA 2020).

3.2.3 Residue Burning

Crop residues can be burned in fields to prepare for cultivation and control for pests, although this is no longer a common practice in the United States (EPA 2020). While CO_2 is a product of residue combustion, residue burning is not considered a net source of CO_2 to the atmosphere because CO_2 released from burning crop biomass is replaced by uptake of CO_2 in crops growing the following season (IPCC 2006). However, CH_4 and N_2O, also products of residue combustion, are not recycled into crop biomass through biological uptake during the following season. Therefore, residue burning is a net source of CH_4 and N_2O to the atmosphere. Overall, GHG emissions from field burning of crop residues are a minor source of emissions in the United States (Table 3-1) (EPA 2020).

3.3 Nitrous Oxide Emissions From Cropland Soils

In 2018, 66 percent of total cropland soil emissions were direct soil N_2O emissions (Table 3-1). Of the 14 percent of total emissions from indirect N_2O, 80 percent are from NO_3 leaching/run off and the remainder are associated with volatilization (Table 3-4). Emissions are highest from row crops (mostly corn and soybean) because row crops cover the largest land area (Map 3-2) and nitrogen inputs are often high from fertilization in rows crops, such as corn, and due to biological fixation in legumes that are grown as row crops, such as soybeans (Figure 3-2). Other factors contributing to high emissions for row crops are that they are grown mostly in the north central region where many of the soils are relatively high in organic matter and some of the soils are poorly drained, both of which enhance denitrification rates. Emissions from irrigated crops had the next highest emissions due to the relatively large area under irrigation management in the United States, and irrigation leads to soils that are typically moist, which can enhance denitrification. Small grain rotations, or cereals, were the third highest, followed closely by grass plus legume hay. Emissions from hay production are substantial, despite minimal fertilizer N additions, because a large portion of hay includes N-fixing plants that increase the available nitrogen in soil as the residues remaining in the field enhance nitrogen availability in the soil (e.g., alfalfa). Emissions from paddy rice are low because the cropland area is small compared to the other crops in the United States. As explained in Section 3-1, partitioning was performed for rotations (Table 3-4) because emissions are related to management practices over the past few years or longer and not just the individual crops that are grown in a specific year. Years beyond 2015 are not included in Table 3-4 and Figure 3-2 because that was the most recent year for which land-use data were available.

Nitrous oxide emissions are largely driven by nitrogen additions and soil organic matter mineralization, weather, and soil physical properties. Nitrogen inputs (i.e., addition of synthetic fertilizers and manure, as well as biological fixation) and mineralization of soil organic matter contributed between ~30.2 and 35.9 MMT N per year to mineral nitrogen availability in cropland soils from 1990 to 2015 (Fig. 3-2), while N_2O emissions varied between 173 and 208 MMT CO_2 eq. However, variation in nitrogen fertilizer inputs explained only about 17 percent of the variability in soil N_2O emissions. Also, the years with highest fertilizer inputs did not necessarily lead to the highest N_2O emissions. This indicates that other factors such as weather strongly influence the annual variability in estimated N_2O emissions. Specifically, amount and timing of precipitation, temperature patterns, and soil carbon availability interact to influence N_2O emissions. Because the responses of N_2O emissions to the controlling variables are often non-linear and the interactions are complex, the correlation, i.e., relationship, is typically weak between any single variable (or even groups of variables) and measured emissions (Stehfest and Bouwman 2006, Nishina et al. 2012, Philibert 2012).

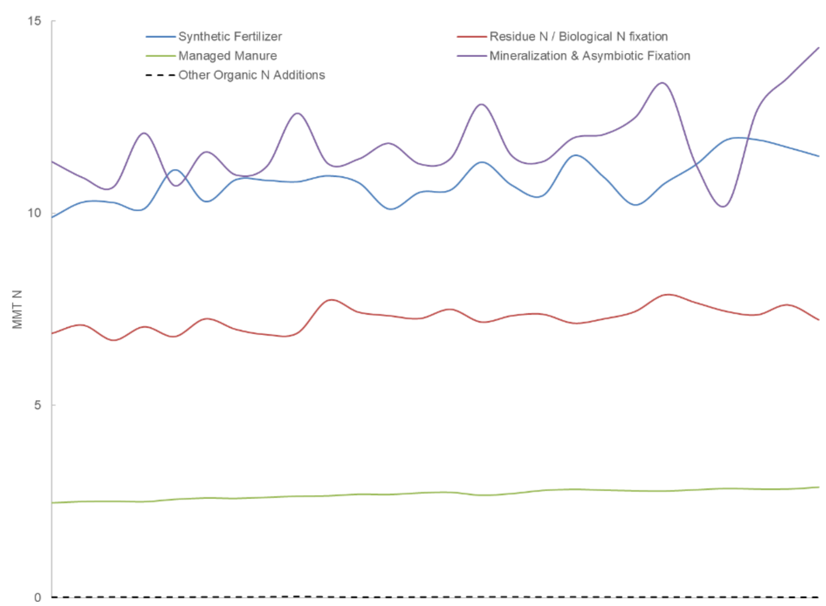


Figure 3-2 Annual Nitrogen Inputs to Cropland Soil, 1990–2015
(MMT N is million metric tons nitrogen)

Table 3-4 Nitrous Oxide Emissions From Cropland Systems[1], 1990, 1995, 2000, 2005, 2013–2015

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System				*MMT CO_2 eq.*				
Tier 3 Method	**194.6**	**190.4**	**180.2**	**187.1**	**194.1**	**206.3**	**216.2**	**207.2**
USDA Conservation Reserve Program	**5.0**	**6.0**	**4.9**	**5.6**	**4.8**	**3.9**	**3.8**	**3.3**
Direct	4.5	5.4	4.5	5.1	4.4	3.6	3.5	3.0
Volatilization	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1
Leaching & Runoff	0.4	0.4	0.2	0.3	0.3	0.2	0.2	0.2
Fallow	**13.4**	**14.4**	**11.2**	**12.1**	**11.3**	**11.2**	**13.0**	**10.5**
Direct	13.1	14.1	10.9	11.8	11.0	10.9	12.7	10.1
Volatilization	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Leaching & Runoff	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.3
Grass Hay	**4.3**	**5.0**	**5.6**	**6.6**	**6.8**	**7.3**	**7.3**	**7.5**
Direct	3.6	4.3	4.8	5.6	5.9	6.2	6.3	6.4
Volatilization	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Leaching & Runoff	0.6	0.6	0.6	0.8	0.8	0.9	0.8	1.0
Legume Hay	**5.0**	**5.4**	**5.7**	**7.0**	**7.3**	**7.6**	**7.6**	**7.6**
Direct	4.3	4.7	5.1	6.1	6.4	6.6	6.8	6.6
Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Leaching & Runoff	0.6	0.6	0.6	0.8	0.8	0.9	0.8	0.9
Hay/Pasture In Rotation	**8.6**	**7.8**	**6.6**	**6.6**	**5.7**	**4.9**	**4.6**	**4.1**
Direct	7.2	6.6	5.7	5.7	4.7	4.1	3.9	3.5
Volatilization	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Leaching & Runoff	1.3	1.1	0.8	0.8	0.8	0.7	0.6	0.6
Irrigated	**20.0**	**22.5**	**23.0**	**24.9**	**25.8**	**26.5**	**27.1**	**27.7**
Direct	17.3	18.5	19.7	21.0	21.3	22.3	22.3	22.0
Volatilization	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7
Leaching & Runoff	2.2	3.5	2.7	3.2	3.9	3.5	4.1	4.9
Low Residue	**5.5**	**6.5**	**6.0**	**5.0**	**4.1**	**4.5**	**4.6**	**4.5**
Direct	4.7	5.5	5.0	4.2	3.5	3.6	3.8	3.7
Volatilization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Leaching & Runoff	0.7	0.9	0.9	0.7	0.5	0.8	0.7	0.8
Other Crops	**9.7**	**7.5**	**7.4**	**5.8**	**6.3**	**8.3**	**8.5**	**7.7**
Direct	8.4	6.5	6.5	5.1	5.5	7.4	7.6	6.8
Volatilization	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Leaching & Runoff	1.1	0.9	0.7	0.5	0.6	0.8	0.7	0.7
Rice	**2.2**	**2.2**	**1.8**	**1.8**	**2.0**	**1.8**	**1.7**	**1.8**
Direct	1.7	1.7	1.5	1.5	1.6	1.5	1.4	1.4
Volatilization	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Leaching & Runoff	0.4	0.4	0.3	0.2	0.3	0.3	0.3	0.3
Row Crops	**93.5**	**88.4**	**88.7**	**92.2**	**99.3**	**110.2**	**118.6**	**114.0**
Direct	75.2	72.1	73.8	76.8	79.9	89.6	97.9	91.7
Volatilization	2.5	2.4	2.9	2.9	3.3	3.3	3.7	3.6
Leaching & Runoff	15.8	13.9	12.0	12.5	16.1	17.3	17.0	18.7
Small Grains	**27.4**	**24.7**	**19.3**	**19.5**	**20.8**	**20.0**	**19.2**	**18.5**
Direct	24.9	22.2	17.7	18.0	19.2	18.4	17.9	16.7
Volatilization	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Leaching & Runoff	2.0	2.0	1.2	1.1	1.2	1.2	0.9	1.5
Tier 1 Method	**21.7**	**23.7**	**23.3**	**25.1**	**25.0**	**26.3**	**25.9**	**32.5**
Direct	17.1	18.4	18.1	19.4	19.3	20.3	20.0	25.0
Volatilization	1.9	2.2	2.2	2.4	2.4	2.4	2.4	3.0
Leaching & Runoff	2.7	3.1	3.0	3.3	3.3	3.5	3.4	4.5
Histosol Cultivation	**3.8**	**3.8**	**3.7**	**3.7**	**3.5**	**3.5**	**3.4**	**3.4**
Total Direct	**185.9**	**183.7**	**177.1**	**184.1**	**186.3**	**198.0**	**207.6**	**200.2**
Total Volatilization	**6.5**	**6.7**	**7.1**	**7.3**	**7.7**	**7.8**	**8.2**	**8.6**
Total Leaching & Runoff	**27.7**	**27.4**	**23.1**	**24.4**	**28.6**	**30.3**	**29.7**	**34.4**
Grand Total	**220.1**	**217.8**	**207.2**	**215.9**	**222.6**	**236.1**	**245.5**	**243.2**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent

[1] Emissions from residue burning are not included. Emissions for cropland systems are based on the analysis using the Tier 3 method. The results for Tier 1 method are provided in aggregate at the bottom of the table.

State-level emissions data are provided in Appendix B. Appendix Table B-1 contains annual N inputs to cropland soils for individual States, and Appendix Table B-2 provides estimates of direct and indirect soil N_2O emissions by State. State-level emissions for cropland management systems are provided for direct N_2O emissions, indirect N_2O emissions from volatilization and indirect N_2O emissions from nitrogen leaching and runoff in Appendix Tables B-8, B-9 and B-10, respectively.

3.3.1 Methods for Estimating N_2O Emissions from Cropland Soils

Emissions of N_2O from nitrogen additions to cropland soils and cultivation of organic Histosol soils are source categories analogous to those covered in Agricultural Soil Management of the United States National GHG Inventory (EPA 2020), with some exceptions. The National GHG Inventory includes direct and indirect emissions of N_2O from soils in grazed lands, while the USDA GHG Inventory includes this source under Livestock GHG Emissions in Chapter 2 of this report.

The DayCent ecosystem model was used to estimate direct soil N_2O emissions, NO_3 leaching, and nitrogen gas volatilization from most cropland area, including mineral soils on non-Federal lands that have less than 35 percent coarse fragments by volume and are used to produce alfalfa hay, barley, corn, cotton, grass hay, grass-clover hay, oats, peanuts, potatoes, rice, sorghum, soybeans, sugar beets, sunflowers, tobacco and wheat. DayCent was also used to estimate emissions for land converted to croplands that were previously grassland but not for conversions from other land uses, such as forestland (EPA 2020). Default Tier 1 emission factors from IPCC (2006) were used to estimate direct and indirect emissions from cropland soils that are not included in the DayCent simulations. Default Tier 1 factors were also used to estimate indirect emissions for leaching and volatilization losses of nitrogen that are later converted into N_2O (Note: DayCent does provide the estimates of nitrogen that are lost from soils through leaching, runoff and volatilization for croplands that were simulated with this model). The default emission factor from IPCC (2006) methodology was also used to estimate emissions from cultivation of organic soils.

Use of a process-based model, such as DayCent, for inventories is known as a Tier 3 approach, while use of IPCC (2006) methodology with default factors is referred to as a Tier 1 approach.

The Tier 1 and 3 methods were applied to estimate emissions from 1990 to 2015, but there were insufficient activity data to use these methods to estimate emissions from 2016 to 2018. Consequently, a data splicing method was applied to estimate the emissions for the last 3 years in the time series. This method is based on a linear regression model with autoregressive moving average (ARMA) errors (Brockwell and Davis 2016). The linear regression model is fit using the 1990 to 2015 emissions data that had been estimated with the Tier 1 and 3 methods, along with surrogate data when available, such as crop production statistics, precipitation and temperature records. Refer to EPA (2020) for a complete description of the methodologies used to estimate N_2O emissions.

3.3.1.1 IPCC Tier 3 DayCent Simulations for Cropland Soils

The DayCent biogeochemical model (Del Grosso et al. 2001, Parton et al. 1998) was used to estimate direct N_2O emissions from most of the cropland area with mineral soils, including croplands used to produce alfalfa hay, barley, corn, cotton, grass hay, grass-clover hay, oats, peanuts, potatoes, sorghum, soybeans, sugar beets, sunflowers, tobacco, and wheat, which represent approximately 85 percent of total cropland in the United States. DayCent simulates crop growth, soil organic matter decomposition, greenhouse gas fluxes, and key biogeochemical processes affecting

N_2O emissions. The simulations are driven by model input data generated from daily weather records, land management, and soil physical properties determined in national soil surveys.

DayCent simulates carbon and nitrogen dynamics, soil water content and temperature, and other ecosystem variables (Parton et al.1987, 1998). Key submodels include: plant growth, senescence of biomass, decomposition of dead plant material and soil organic matter, and mineralization of nitrogen. Model inputs are monthly maximum/minimum air temperature and precipitation, surface soil texture class, soil hydric condition, vegetation type, and land management information (e.g., cultivation timing and intensity, timing and amount of fertilizer and organic matter amendments). Soil organic matter is simulated to a depth of 30 cm (Gurung et al. 2020), while water, temperature, and mineral nitrogen are simulated throughout the soil profile. Soil organic matter is divided into three pools based on decomposability: active (turns over in months to years), slow (turns over in decades), and passive (turns over in centuries). The model accounts for the effects of nutrient availability, water, and temperature on plant growth (CO_2 uptake) and the effects of these factors, as well as cultivation, on decomposition (CO_2 release). The ability of the model to integrate carbon gains and losses and simulate plant growth and soil carbon levels reliably has been demonstrated using data from many sites in the United States and around the world (Parton et al.1994, Cerri et al. 2007, Ogle et al. 2007). The model has been shown to work in all the major biomes of the earth and can accurately reproduce the impacts of climate, soil texture, and land management on carbon fluxes (Parton et al. 1993, Kelly et al. 1997, Lugato 2007, Bricklemyer 2007). DayCent has been parameterized to represent major commodity crops, as well as many specialty crops, grown in the United States. However, the model has not been parameterized to simulate all crops, and the model also is not structured to simulate GHG emissions for any crops grown on organic soils.

DayCent simulations were conducted using the cropping and land-use histories for survey locations in the National Resources Inventory (NRI) (USDA 2018a). The NRI is a statistically based sample of all non-Federal land and includes 349,464 survey points in agricultural land for the conterminous United States. Each survey point is associated with an expansion factor that allows scaling of N_2O emissions from NRI survey locations to the entire country (i.e., each expansion factor represents the amount of area with similar land-use/management history as the sample point). Land use and some management information (e.g., crop type, soil attributes, and irrigation) were originally collected for each NRI point on a 5-year cycle beginning in 1982. For cropland, data were collected for 4 out of 5 years in the cycle (i.e., 1979–1982, 1984–1987, 1989–1992, and 1994–1997). In 1998, the NRI program began collecting annual data, and at the time of this report's analysis, data were available through 2015.

The simulations reported here assumed intensive tillage management, gradual improvement of cultivars, and gradual increases in fertilizer application from 1950 until 1978. We accounted for improvements of cultivars (cultivated varieties) because it is unrealistic to assume that current crop varieties are identical to earlier varieties because of crop breeding management that has increased yield potential, nitrogen demand, and other crop characteristics. Realistic simulations of historical land management and vegetation types are important because they influence present day soil carbon and nitrogen levels, which influence present day nitrogen cycling and associated N_2O emissions. In addition to simulating historical crop management, the model also represented at least 1,000 years of native vegetation before land was cultivated for crop production.

Nitrous oxide emission estimates from DayCent include the influence of nitrogen additions, crop type, irrigation, and other factors in aggregate, and therefore it is not possible to accurately partition N_2O emissions by anthropogenic activity (e.g., N_2O emissions from synthetic fertilizer applications cannot be reliably distinguished from those resulting from manure applications). Consequently, emissions are not subdivided according to activity (e.g., N fertilization, manure amendments), as is suggested in the IPCC *Guidelines*, but the overall estimates are more accurate than the more simplistic Tier 1 method based on model testing (EPA 2020). The main limitation of the Tier 1 method is that this approach is not capable of addressing the broader set of driving variables influencing N_2O emissions. Thus, DayCent forms the basis for a more complete estimation of N_2O emissions than is possible with the Tier 1 methodology.

3.3.1.2 Sources of Uncertainty for DayCent Simulations

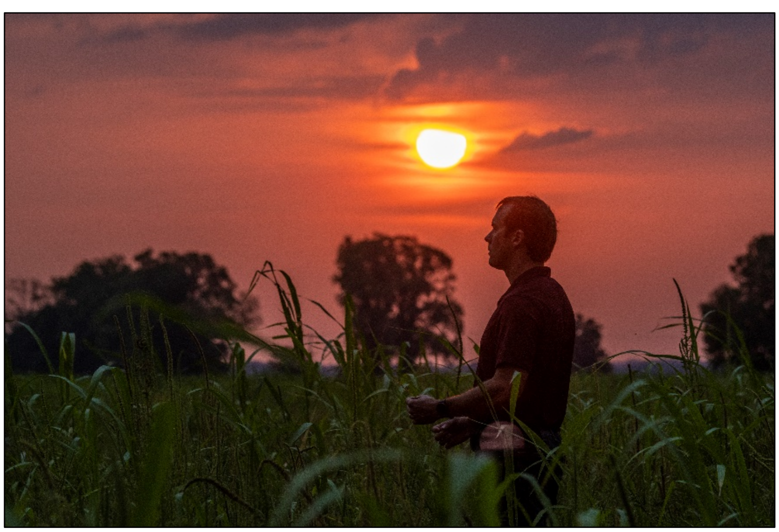
The DayCent model results imbed three types of uncertainty: management input uncertainty, model structural uncertainty, and land-area scaling uncertainty. Uncertainty in management inputs, such as tillage practices and mineral fertilization rates, was addressed using Monte Carlo analysis with 1,000 iterations (Del Grosso et al. 2010, EPA 2020). The management input data product for DayCent was compiled using machine-learning methods and by combining information from several datasets (discussed further in Section 3.3.2.3). This product contained six representations of management practices for the entire NRI survey dataset, capturing uncertainty associated with the underlying datasets. These six representations were randomly selected in the Monte Carlo simulation to propagate the management input error through the analysis, along with the other two sources of uncertainty discussed below.

Model structural error is due to imperfect representation of reality in the model's mathematical framework. That is, models contain simplifying assumptions and imperfectly represent the processes that control crop growth, carbon and nitrogen dynamics, water flows, and N_2O emissions. This component is the largest source of uncertainty in the Tier 3 model-based inventory analysis, accounting for more than 80 percent of the overall uncertainty in the final estimates (Ogle et al. 2010, Del Grosso et al. 2010). To quantify model structural error and associated parameterization uncertainty, N_2O emissions generated by DayCent were compared with emissions measured at 64 sites with 796 combinations of fertilizer treatments and cultivation practices from experiments conducted in the United States and additional sites from other countries with similar climates and soils to increase the power of the analysis. Specifically, an empirically based procedure was applied to develop a structural uncertainty estimator from the relationship between modeled predictions of N_2O emissions and field measurements (Ogle et al. 2007, EPA 2020). Model inputs are assumed to be precisely known for the experiments so structural uncertainty can be isolated. Probability distributions were derived using linear-mixed models, and then used to estimate 1,000 time series of emissions for each NRI survey location that incorporates a correction for bias and measure of precision in the DayCent model predictions of N_2O emissions from 1990 through 2015.

The third element is the uncertainty associated with scaling the DayCent results for each NRI survey location to the entire land base by using the expansion factors provided with the NRI dataset. The expansion factors represent the number of hectares associated with the land use and management history for a particular survey point. This uncertainty is determined by computing the variances from a set of replicated weights for the expansion factor and combined in the Monte Carlo simulation with the uncertainty in management input data and model structure and parameterization.

3.3.1.3 Activity Data for DayCent Simulations

The National Resources Inventory provided land use and cropping history information for the DayCent simulations. The NRI has a stratified two-stage sampling design, where primary sample units are stratified on the basis of county and township boundaries defined by the Public Land Survey (Nusser and Goebel 1997). Within a primary sample unit, typically a 160-acre (64.75 ha) square quarter-section, three sample points are selected according to a restricted randomization procedure. Each point in the survey is assigned an expansion factor based on other known areas and land-use information (Nusser and Goebel 1997). In principle, the expansion factors represent the amount of area with the land use and land-use change history that is the same as the survey point location. It is important to note that the NRI uses a sampling approach, and therefore there is uncertainty associated with scaling the survey point data to a region or the country using the expansion factors that can be derived using standard survey statistical methods. In general, those uncertainties decline at coarser scales, such as States compared to smaller county units, because of a larger sample size.



An extensive amount of soils, land use, and land management data have been collected through the NRI survey (Nusser et al. 1998). Primary sources for data include aerial photography and remote sensing imagery as well as field visits and county office records. In addition to providing land cover information, NRI differentiates between irrigated and non-irrigated land, but does not provide more detailed information on the type and intensity of irrigation. Hence, irrigation is modeled by assuming that water is applied to reach field capacity with intervals between irrigation events determined by assuming that irrigation events occur when the soils drain to about 60 percent of field capacity. The annual NRI data product provides crop data from 1979 to 2015. NRI survey points are included in the land base for the agricultural soil N_2O emissions inventory if they were identified as cropland or grassland between 1990 and 2015. Note that the NRI includes only non-Federal lands because Federal lands are not classified into land uses as part of the NRI survey (i.e., they are only designated as Federal lands).

Management data from 1978 through 2015 were based on a combination of the first USDA Conservation Effects and Assessment Project (CEAP-1), Agricultural Resource Management Surveys (ARMS), Conservation Technology Information Center (CTIC) surveys, USDA Census of Agriculture, and EPA Manure Management dataset. CEAP-1 provides data on tillage practices, mineral fertilization, manure amendments, cover crop management, planting, and harvest dates collected between 2003 and 2006 through farm-level surveys (USDA 2018b). These data are collected on a subsample of the NRI and can be used to infer management across the entire NRI survey for croplands.

However, CEAP only provides information about management in the early 2000s so these data are combined with the other datasets to impute estimates for the entire time series of management activity from 1990 through 2015. ARMS data are used to inform the inventory about synthetic fertilizer management (USDA-ERS 2018) across the remaining time series, in combination with USDA cropping surveys that preceded the ARMS surveys (USDA 1997a). Tillage practices prior to 2000 are based on CTIC surveys (CTIC 2004) and then ARMS data provide information about tillage after the CEAP survey (Claassen et al. 2018). CEAP provides information on cover crops that is combined with USDA Census data on planted cover crop area through 2015 (USDA 2012, 2017). There are no data on cover crop area prior to 2000 so it is assumed that cover crops were not commonly used prior to 1990 and increased linearly to the levels in the first year of the CEAP survey around 2002. The EPA Manure Management dataset provides information on the amount of manure available for applications to croplands EPA (2020) and is combined with the CEAP data to complete the time series of manure amendments to cropland soil. The information in these datasets are combined in a single management activity product for the NRI survey locations with cropland using statistical imputation approaches with machine learning methods (See EPA 2020 for more information).

Daily maximum/minimum temperature and precipitation data are based on gridded weather data from the PRISM Climate Data product (PRISM Climate Group 2018). Since weather station data do not exist near all NRI survey locations, it is necessary to use computer-generated weather station data that is interpolated across the entire domain containing NRI survey locations. The PRISM product uses this information with interpolation algorithms to derive weather patterns for areas between these stations. PRISM weather data are available for the United States from 1981 through 2015 at a 4 km resolution, and each NRI survey location is assigned PRISM weather data using geographic information system software.

Soil texture and natural drainage capacity (i.e., hydric versus non-hydric soil characterization) are the main soil variables used as input to the DayCent model. Texture is one of the main controls on soil processes in the DayCent model, which uses particle-size fractions of sand (50–2,000 µm), silt (2–50 µm), and clay (< 2 µm) as inputs. Hydric soils are poorly drained and hence prone to have a high-water table for part of the year in their native (pre-cultivation) condition. Non-hydric soils are moderately to well drained.[2] Poorly drained soils can be subject to anaerobic (lack of oxygen) conditions if water inputs (precipitation and irrigation) exceed water losses from drainage and evapotranspiration. Depending on moisture conditions, hydric soils can range from being fully aerobic to completely anaerobic, varying over the year. Other soil characteristics needed for simulations, such as field capacity and wilting-point water contents, are estimated from soil texture data using a standardized hydraulic properties calculator (Saxton et al. 1986). Soil input data are derived from Soil Survey Geographic Database (SSURGO) (Soil Survey Staff 2019). The data are based on field measurements collected as part of soil survey and mapping. Each NRI survey point is assigned the dominant soil component in the polygon containing the point from

[2] Artificial drainage (e.g., ditch- or tile-drainage) is simulated as a management variable.

the SSURGO data product using geographic information system software.

3.3.2 IPCC Tier 1 Methodology for Cropland Not Simulated by DayCent

3.3.2.1 Mineral Soils

For mineral agricultural soils that are not simulated by DayCent, the Tier 1 IPCC methodology was used to estimate direct N_2O emissions. Estimates of direct N_2O emissions from nitrogen applications to non-major crop types were based on the annual increase in mineral soil nitrogen from the following practices: (1) the application of synthetic commercial fertilizers, (2) the retention of crop residues, and (3) and non-manure organic fertilizers.

Annual synthetic fertilizer nitrogen additions to cropland not simulated by DayCent are calculated by process of elimination. For each year, fertilizer applied to cropland and grazed lands simulated by DayCent was subtracted from total fertilizer used on farms in the United States. The difference was assumed to be applied to cropped land not simulated by DayCent. Residue nitrogen for these crops was derived from information on crop production yields, residue management (retained versus burned or removed), mass ratios of aboveground residue to crop product, dry matter fractions, and nitrogen contents of the residues (IPCC 2006). The activity data for these practices included crop yield data from USDA crop production reports (USDA 2017), along with nitrogen contents of residues and roots, dry matter fractions, ratios of aboveground to belowground root biomass from IPCC (IPCC 2006)).

Estimates of total national annual nitrogen additions from land application of other organic fertilizers were derived from organic fertilizer statistics (TVA 1991–1994, AAPFCO 1995–2017). The organic fertilizer data, which are recorded in mass units of fertilizer, had to be converted to mass units of nitrogen by multiplying by the average organic fertilizer nitrogen contents provided in the annual fertilizer publications. These nitrogen contents are weighted average values and vary from year-to-year (AAPFCO 1995–2017). Annual on-farm use of these organic fertilizers is very small, less than 0.02 MMT of nitrogen.

IPCC Tier 1 methodology for emissions from mineral soils is based on nitrogen inputs. Nitrogen inputs from synthetic and organic fertilizer and aboveground and belowground crop residues were added together. This sum was multiplied by the default Tier 1 emission factor (1.0 percent) to derive an estimate of cropland direct N_2O emissions from non-major crop types. Nitrate leached or run off and nitrogen volatilized from non-major crop types are calculated by multiplying nitrogen fertilizer applied by the Tier 1 default factors (30 percent and 10 percent, respectively).

3.3.2.2 Cultivation of Histosols

The IPCC Tier 1 method was used to estimate direct N_2O emissions from the drainage and cultivation of organic cropland soils. Estimates were obtained from the NRI of the total national acreage of drained organic soils cultivated annually for temperate and subtropical climate regions (USDA 2018a). The classification of temperate and subtropical climates are based on data from the WorldClim data set (Hijmans et al. 2005) and potential evapotranspiration data from the Consortium for Spatial Information (CGIAR-CSI) (Zomer et al. 2008; Zomer et al. 2007). To estimate annual N_2O emissions from cultivation of Histosols, the temperate area is multiplied by the IPCC default emission factor for temperate soils (8 kg N_2O-N/ha cultivated; IPCC 2006), and the subtropical area is multiplied by the average of the temperate and tropical IPCC default emission factors (12 kg N_2O-N/ha cultivated; IPCC 2006).

3.3.2.3 Total N_2O Emissions

Total direct emissions were obtained by summing the following results, (a) emissions estimated from the DayCent simulations for mineral soils, (b) Tier 1-based estimates for crops on mineral soils not simulated by DayCent, and (c) the Tier 1 estimates of emissions from organic soils (i.e., Histosols). Total indirect emissions from NO_3 leaching or run off in landscapes where annual water inputs from precipitation and irrigation exceed potential evaporation rates were obtained by adding emission estimated with DayCent simulations for mineral soils to Tier 1 default estimates for crops on mineral soils that are not simulated by DayCent and multiplying by the default emission factor (0.75 percent of N leached/run off). Similarly, total indirect emissions from nitrogen volatilization were obtained by adding emissions estimated from the DayCent simulations for mineral soils to Tier 1 estimates for crops on mineral soils that are not simulated by DayCent, and then multiplying the total by the default emission factor (1 percent of N volatilized).

Table 3-5 Methane From Rice Cultivation by State, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018	% Change[1]
States						*MMT CO_2 eq.*						
Arkansas	5.4	5.4	6.3	7.9	8.9	4.7	5.7	6.4	5.0	4.7	4.9	-8%
California	3.3	3.4	3.7	3.4	3.4	3.7	3.9	4.1	3.5	3.3	3.4	5%
Florida	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Illinois	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Kentucky	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Louisiana	2.6	2.4	3.0	2.8	2.7	2.2	3.2	2.6	2.4	2.3	2.4	-8%
Minnesota	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-48%
Mississippi	1.1	1.3	1.3	1.4	1.1	0.8	0.8	1.0	0.8	0.7	0.8	-32%
Missouri	0.6	0.5	1.1	1.1	1.4	0.8	0.8	0.7	0.7	0.6	0.7	22%
New York	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100%
South Carolina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Tennessee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Texas	3.0	3.4	2.0	1.3	1.3	1.5	0.9	1.4	1.1	1.1	1.1	-63%
Total	**16.0**	**16.5**	**19.0**	**18.0**	**18.9**	**13.8**	**15.4**	**16.2**	**13.5**	**12.8**	**13.3**	**-17%**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent

[1] Change from 1990 to 2018

Indirect emissions from NO_3 leaching or run off were added to those from nitrogen volatilization to estimate total indirect emissions. Total direct and indirect emissions were then summed to obtain total N_2O emissions from cropland soils.

3.3.3 Uncertainty in N_2O Emissions

Uncertainty was combined for direct emissions from croplands simulated by DayCent, croplands that are estimated with the Tier 1 method (i.e., not simulated with DayCent), and indirect emissions from croplands. Section 3.3.2.2 describes uncertainty for direct emissions estimated using DayCent. Uncertainty for direct emissions from croplands that are not simulated by DayCent was estimated using simple error propagation (IPCC 2006), by combining uncertainty in the default emission factor with uncertainty in the nitrogen inputs to cropland soils.

Uncertainty in indirect emissions for croplands simulated by DayCent were estimated by combining uncertainty in DayCent estimates of nitrate leaching and nitrogen gas volatilization (See Section 3.3.2.2) with uncertainty in the IPCC Tier 1 N_2O emissions factors. Uncertainty in indirect emissions for croplands that are not simulated by DayCent combined uncertainty in IPCC Tier 1 factors for nitrate leaching and N gas volatilization with uncertainty in the IPCC Tier 1 N_2O emissions factors. The simple error propagation was used to combine uncertainties in the various components by taking the square root of the sum of the squares of the standard deviations of the components (IPCC 2006). There is also additional uncertainty associated with the data splicing methods that are applied to approximate emissions from 2016 through 2018 (See EPA 2020 for more information). The 95-percent confidence intervals in N_2O emissions were estimated to range between 131 and 294 MMT CO_2 eq. for direct emissions and between 11 and 159 MMT CO_2 eq. for indirect emissions (Table 3-1).

3.3.4 Changes Compared to the 4th Edition of the USDA GHG Report

There were several changes compared to the previous edition of the inventory. Due to the absence of annual management practice data, the most important was incorporating the latest NRI survey data for land use information and developing the management activity data imputation product by combining management information from the CEAP survey with ARMS, CTIC, Agricultural Census, and the EPA manure management data.

Other key changes are related to improvements in the DayCent model and uncertainty estimation. The most noteworthy of these changes relates to expanding the number of study sites used to quantify model uncertainty for direct N_2O emissions. There were also various changes to the DayCent model, including modifying algorithms to more realistically represent plant and soil processes and modifying parameters to improve model outputs. In particular, the impact of freeze-thaw cycles on N_2O emissions was incorporated into DayCent to simulate the large pulses of emissions, often referred to as hot moments of emissions, which occur during spring thaw events (Wagner-Riddle et al. 2017). These changes resulted in an increase in N_2O emissions of approximately 35 percent, relative to the previous inventory.

3.3.5 Mitigation of N_2O Emissions

Mitigation of N_2O emissions is based on optimizing the amount and timing of nitrogen fertilizer additions, in addition to the type of fertilizer. Excess fertilizer applied to crops increases the nitrogen available for N_2O, nitrogen oxide, NH_3 emissions and NO_3 leaching, and research has shown that there is an exponential increase in N_2O emissions if excess fertilizer is applied to crops beyond the amount required to meet yield potentials (Shcherbak et al. 2014). Using enhanced efficiency fertilizer types designed to release nitrogen slowly or formulated with nitrification inhibitors and applying fertilizer in multiple applications improves the synchrony between nitrogen supply and plant nitrogen demand. However, multiple applications of fertilizer require increased time and equipment usage by farmers and enhanced efficiency fertilizers are more expensive than conventional fertilizers. While use of nitrification inhibitors and slow-release fertilizers has been shown to decrease N_2O emissions in some systems (Migliorati et al. 2015, Halvorson et al. 2014, Akiyama et al. 2010, Weiske et al. 2001, McTaggert et al. 1997), use of these improved fertilizers does not always result in reductions of N_2O (Parkin and Hatfield 2014, Dell et al. 2014, Sistani et al. 2011). There is some evidence that these fertilizers are more effective in irrigated systems and when rainfed systems receive consistent precipitation (Hatfield and Venterea 2014). Climate-specific scaling factors have been developed to represent the expected direct N_2O reduction for enhanced efficiency fertilizers and are reported in a USDA report in greenhouse gas inventory methods (Ogle et al. 2014). Ogle et al. (2014) also includes scaling factors for the expected reductions in NO_3 leaching, which contributes to indirect N_2O emissions, for leguminous and non-leguminous cover crops.

3.4 Methane Emissions From Rice Cultivation

Methane (CH_4) emissions from rice cultivation[3] mostly occur in two regions, California and the southern portion of the Mississippi River Valley (Arkansas, Mississippi, and Louisiana) and adjoining eastern Texas (Figure 3-3). Overall, rice cultivation is a small source of CH_4 in the United States. In 2018, CH_4 emissions totaled 13.3 MMT CO_2 eq. (Table 3-5).Arkansas and California had the highest CH_4 emissions (4.9 MMT CO_2 eq. and 3.4 MMT CO_2 eq. respectively) from rice cultivation in 2018, followed by Louisiana, Missouri, Mississippi, and Texas, which had emissions ranging from 0.7 to 2.4 MMT CO_2 eq. (Table 3-5). State-level shifts in CH_4 emissions are correlated with changes in area of rice cultivation (Appendix Table B-3). For example, since 1990, CH_4 emissions from rice cultivation have decreased by nearly 17 percent, while total area of rice cultivation has decreased by about 20 percent. Among States with higher CH_4 emissions, Texas accounts for most of the overall reduction, with a decline of 63 percent (Table 3-5).

Appendix Table B-3 provides a time series of rice cultivation areas for each State. State-level estimates of CH_4 emissions from rice cultivation are provided in Appendix Table B-4.

[3] This source focuses on CH_4 emissions resulting from anaerobic decomposition and does not include emissions from burning of rice residues. The latter is covered in section 3.5.

3.4.1 Methods for Estimating CH_4 Emissions from Rice Cultivation

Methane emissions from rice cultivation are estimated with the DayCent model by simulating plant production, water flows, temperature regimes and soil processes including methanogensis, which drives CH_4 emissions from flooded soils (Cheng et al. 2013). More detail about the simulation framework is given in Section 3.1.1, and also can be found in EPA (2020). Rice systems are simulated with DayCent if the cropland is continuous rice or rice is grown in rotation with other crops that can be simulated with DayCent (See Section 3.1.1 for the list of crops). DayCent is also used to simulate rice cultivation following conversion from grassland, but not for conversions from other land uses, such as forestland.

The IPCC Tier 1 method was used to estimate CH_4 emissions for croplands that are not simulated with DayCent. This method uses default factors and is based on scaling a base emission rate for continuous flooded rice croplands with no organic amendments using factors for specific water management practices and organic amendment rates (IPCC 2006).

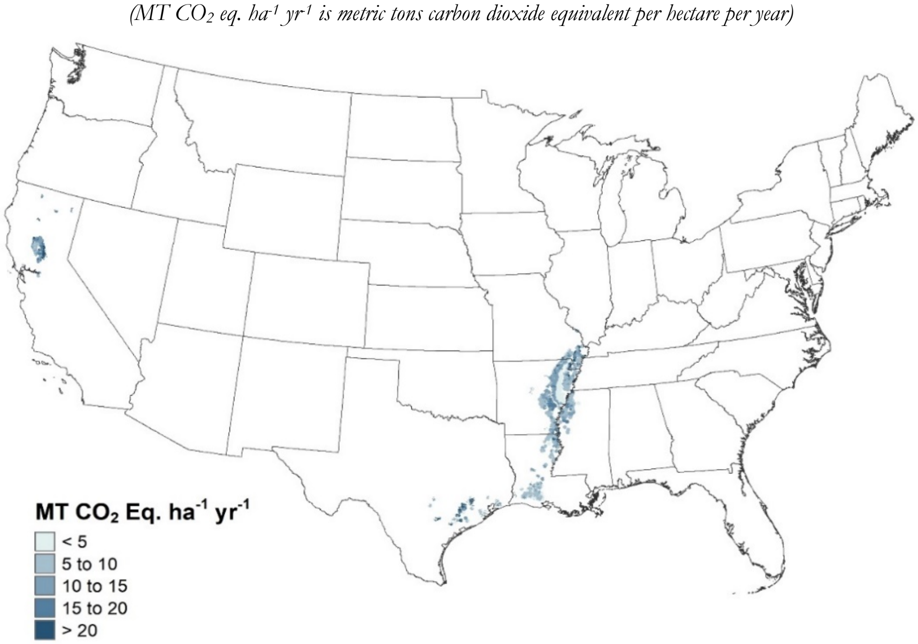
As with soil nitrous oxide, the Tier 1 and 3 methods were applied to estimate CH_4 emissions from rice cultivation between 1990 to 2015, but there were insufficient activity data to estimate emissions from 2016 to 2018 with these methods. Consequently, a data splicing method was applied to estimate the emissions for the last 3 years in the time series based on a linear regression model with autoregressive moving-average (ARMA) errors (Brockwell and Davis 2016). The model is fit using the 1990 to 2015 emissions data that had been estimated with the Tier 1 and 3 methods, along with surrogate data, such as crop production statistics, precipitation, and temperature records. Refer to EPA (2020) for a complete description of the methodologies used to estimate CH_4 emissions from rice cultivation.

3.4.2 Uncertainty in Estimating Methane Emissions from Rice Cultivation

Uncertainty in DayCent estimates of CH_4 emissions was calculated using the methods described in Section 3.3.2.2. Similar to soil N_2O emissions, a larger portion of the uncertainty is associated with model structure, which was quantified with an empirical method (Ogle et al. 2007). This method is based on comparing model predictions to measured emissions from 17 experiments with 238 observations of CH_4 emissions to quantify the accuracy and precision in model predictions. Uncertainty in the Tier 1 method was derived based on simple error propagation methods that combine the uncertainties in emission factors and activity data. Simple error propagation was also used to quantify the uncertainty in the total emissions, combining the estimated emissions from the Tier 1 and 3 methods (See Section 3.3.3 for more information about the simple error propagation methods). There is also additional uncertainty associated with the data splicing methods that are applied to approximate emissions from 2016 through 2018 (See EPA 2020 for more information). Rice cultivation CH_4 emissions in 2018 were estimated to be between 9 and 22 MMT CO_2 eq. at a 95-percent confidence level for the emission estimate of 13 MMT CO_2 eq.

Map 3-2 Rice Cultivation Methane Emissions From Cropland, 2015

(MT CO_2 eq. ha^{-1} yr^{-1} is metric tons carbon dioxide equivalent per hectare per year)



Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. This map is reprinted from EPA (2020).

Table 3-6 Greenhouse Gas Emissions From Agriculture Burning by Crop, 1990, 1995, 2000, 2005, 2010, 2013–2018

	1990	1995	2000	2005	2010	2013	2014	2015	2016	2017	2018
Source	MMT CO_2 *eq.*										
CH_4	**0.34**	**0.28**	**0.32**	**0.39**	**0.42**	**0.39**	**0.40**	**0.40**	**0.40**	**0.40**	**0.39**
Corn	0.06	0.05	0.08	0.08	0.11	0.12	0.12	0.11	0.11	0.11	0.11
Rice	0.07	0.05	0.04	0.08	0.09	0.03	0.07	0.06	0.06	0.06	0.06
Wheat	0.13	0.10	0.11	0.13	0.11	0.13	0.10	0.12	0.12	0.12	0.12
Barley	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Small Grains	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Sorghum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cotton	0.02	0.03	0.03	0.04	0.03	0.02	0.02	0.03	0.03	0.03	0.03
Legume Hay + Grass Hay	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Peanuts	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Soybeans	0.02	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Other Crops	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
N_2O	**0.15**	**0.13**	**0.15**	**0.17**	**0.18**	**0.17**	**0.18**	**0.18**	**0.17**	**0.18**	**0.17**
Corn	0.02	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rice	0.03	0.02	0.02	0.03	0.04	0.01	0.03	0.03	0.02	0.03	0.02
Wheat	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Small Grains	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cotton	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Legume Hay + Grass Hay	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Peanuts	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Soybeans	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Other Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.49**	**0.41**	**0.47**	**0.57**	**0.60**	**0.56**	**0.58**	**0.58**	**0.57**	**0.57**	**0.57**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent

3.4.3 Changes Compared to the 4th Edition of the USDA GHG Report

The methodology was revised to incorporate the Tier 3 method using the DayCent model after methanogenesis methods were developed and tested in various regions of the world (Cheng et al. 2013, Cheng et al. 2014, EPA 2020). DayCent incorporates more drivers of emissions in a process-based approach than is possible with the simple empirical models that were used in the previous USDA GHG inventory report. Furthermore, the Tier 1 method with default factors was used to estimate CH_4 emissions from rice croplands that were not estimated with DayCent. The previous Tier 2 method had limited data for developing factors, and it was decided to not use this method in the latest inventory, although this method can be explored further with more experimental measurement data in the future. Methane emissions increased by about 85 percent based on these changes to the inventory methods.

3.5 Residue Burning

Greenhouse gas emissions from field burning of crop residues are a function of the amount and type of residues burned. Emissions from residue burning are a small source of overall crop-related emissions in the United States (Table 3-1, Table 3-6). The relatively small amount of emissions associated with residue burning is due to the fact that only a small portion of residues are burned each year (Figure 3-3a, Figure 3-3b). Roughly one-third of GHG emissions from residue burning, across all crop types, consisted of CH_4 in 2018, and the remaining emissions were N_2O (Table 3-6). The highest GHG emissions were from burning of wheat crop residues at 23 percent of total emissions, following by corn crop residues at 20 percent. Burning of rice, cotton, and soybean crop residues each contributed from 5 to 15 percent of total GHG emissions, while other crops contributed less than 5 percent.

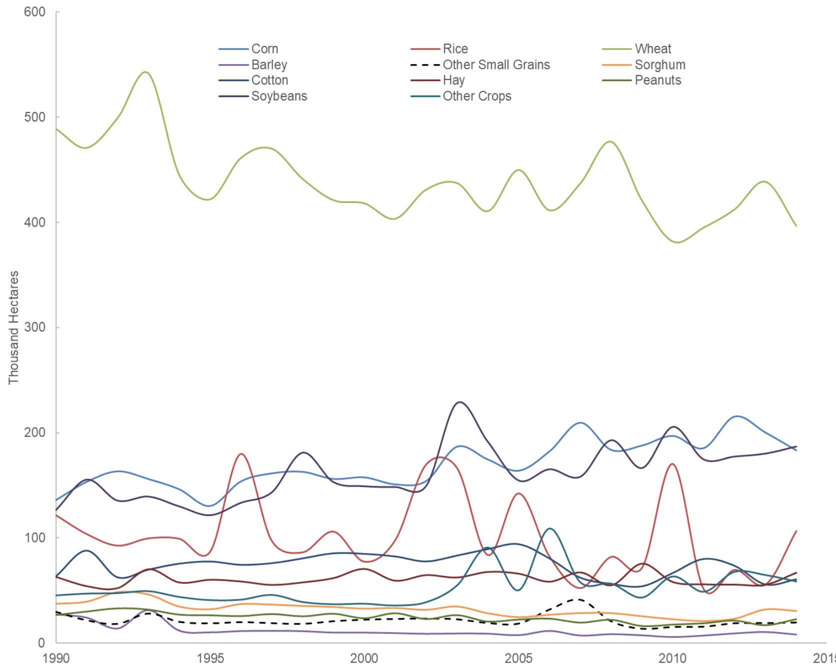


Figure 3-3a Total Area With Residue Burning Management, 1990–2014

Total GHG emissions from residue burning increased by 16 percent from 1990 to 2018, but contributed a small amount of additional emissions, estimated at 0.08 MMT CO_2 eq. This trend was largely driven by slight increases in burning of corn and soybean residues (Figure 3-3a). Appendix Tables B-2 and B-4 provide N_2O and CH_4 emissions from crop residue burning by State. Appendix Table B-3 provides estimates of the amount of residue burning by State.

3.5.1 Methods for Estimating CH_4 and N_2O Emissions from Residue Burning

A Tier 2 method (EPA 2020) was used to estimate greenhouse gas emissions from field burning of agricultural residues. The method utilizes data on crop production from USDA National Agricultural Statistics Service (USDA 2017) to estimate the amounts of residues produced for the crops that are managed with residue burning. The method uses conversion factors based on relationships between crop yield and total aboveground biomass of the crop to approximate the amounts of residues that are left in the field after crop harvest.

The amount of area that is managed with residue burning for each crop is determined for the survey locations that are identified as cropland in the National Resources Inventory (NRI) (USDA 2018a; See Section 3.3.2.3 for more information about the NRI). NRI has compiled crop histories for a random sample of 349,464 locations across the United States. Burning management is determined for a subsample of the NRI cropland locations using remote-sensing data products, including LANDFIRE data products developed from 30m Landsat imagery (LANDFIRE 2014) and Moderate Resolution Imaging Spectroradiometer imagery (MODIS) Global Fire Location Product (MCD14ML). A statistical model is then used to infer burning histories across the entire NRI survey that is cropland.

The Tier 2 method was applied to estimate emissions from 1990 to 2014, but there were insufficient activity data to use this method to estimate emissions from 2015 to 2018. Therefore, a data splicing method was applied to estimate the emissions for the last 4 years in the time series. Refer to EPA (2020) for a complete description of the methodologies used to estimate CH_4 and N_2O emissions from residue burning.

3.5.2 Uncertainty in Estimating Methane and Nitrous Oxide Emissions from Residue Burning

A Monte Carlo analysis was performed to quantify uncertainties in the emissions. The analysis incorporated uncertainties in the NRI survey data and likelihood of burning management at survey locations, as well as uncertainties in the conversion factors to estimate residue amounts, and uncertainties in the emissions factors. There was also additional uncertainty associated with the data splicing methods that are applied to approximate emissions from 2016 through 2018 (See EPA 2020 for more information).The 95-percent confidence interval was 0.1 to 0.2 MMT CO_2 eq. for the estimated N_2O emissions of 0.2 MMT CO_2 eq. and 0.3 to 0.5 MMT CO_2 eq. for the estimated CH_4 emissions of 0.4 MMT CO_2 eq. (Table 3-1).

3.5.3 Changes Compared to the 4th Edition of the USDA GHG Report

The methodology was revised from the previous inventory with the analysis to estimate the area burned based on the LANDFIRE (LANDFIRE 2014) and

Table 3-7 Soil Organic Carbon Stock Change for Cropland Systems[1], 1990, 1995, 2000, 2005, 2010, 2013–2015

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System[1]				*MMT CO_2 eq.*				
Tier-3	**(57.4)**	**(41.3)**	**(48.1)**	**(58.3)**	**(44.2)**	**(40.2)**	**(37.3)**	**(36.1)**
USDA Conservation Reserve Program	(7.1)	(9.9)	(7.3)	(7.8)	(7.0)	(4.9)	(3.9)	(3.8)
Fallow	0.8	2.0	1.5	1.7	2.1	2.6	2.8	2.6
Grass Hay	(7.8)	(9.7)	(9.0)	(9.8)	(8.9)	(8.0)	(8.5)	(8.8)
Legume Hay	(6.1)	(5.9)	(6.4)	(7.0)	(5.9)	(5.8)	(5.6)	(6.3)
Hay/Pasture In Rotation	(7.8)	(5.7)	(6.0)	(3.7)	(2.5)	(3.0)	(2.0)	(2.3)
Irrigated	(6.9)	(4.2)	(5.7)	(5.8)	(3.7)	(5.1)	(3.2)	(2.1)
Low Residue	(0.2)	1.1	0.8	(0.9)	1.0	1.6	1.7	2.0
Other Crops	(3.9)	(0.5)	(4.5)	(1.9)	(2.7)	(4.2)	(3.8)	(2.3)
Rice	0.1	(0.1)	(0.3)	(0.5)	(0.7)	(0.4)	(0.2)	(0.4)
Row Crops	(15.8)	(6.8)	(8.8)	(20.3)	(16.4)	(13.7)	(14.9)	(16.0)
Small Grains	(2.8)	(1.6)	(2.4)	(2.3)	0.5	0.7	0.3	1.3
Tier-2 Mineral Soils	**1.5**	**1.7**	**1.1**	**(2.8)**	**(2.3)**	**(3.3)**	**(3.0)**	**(3.8)**
Tier-2 Organic Soils	**38.6**	**38.6**	**32.5**	**37.7**	**36.1**	**35.3**	**36.3**	**35.8**
Mineral Total	**(55.8)**	**(39.6)**	**(47.0)**	**(61.1)**	**(46.5)**	**(43.5)**	**(40.3)**	**(39.9)**
Organic Total	**38.6**	**38.6**	**32.5**	**37.7**	**36.1**	**35.3**	**36.3**	**35.8**
Grand Total	**(17.2)**	**(1.0)**	**(14.6)**	**(23.4)**	**(10.4)**	**(8.2)**	**(4.0)**	**(4.1)**

Note: Parentheses indicate a net sequestration. MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1] Soil organic carbon stock changes are for cropland systems that are estimated using the Tier 3 method. The results for Tier 2 method are provided in aggregate at the bottom of the table. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. Does not include emissions from urea application and liming.

MODIS Global Fire Location Products (Giglio et al. 2006). These data were used to determine burning histories for a subset of NRI survey locations from 1990 to 2014, and then a statistical model was used to infer burning histories across the other NRI survey locations designated as cropland. This major change resulted in an average increase in CH_4 emissions of about 22 percent and an average increase in N_2O emissions of about 67 percent across the time series, compared to the previous inventory.

3.6 Carbon Stock Changes in Cropland Soils

Except for cultivated organic soils, urea fertilization and liming practices, cropland soils in the United States have accumulated, or sequestered, about 46 MMT CO_2 eq. in 2018 (Table 3-1)[4]. Much of the carbon sequestration is attributable to row crop management systems and land used to grow hay (Table 3-7). The management practices with the largest impact on carbon sequestration include conservation tillage, setting aside cropland from production (i.e., through enrollment in the Conservation Reserve Program), amending soils with manure, and including hay and pasture in rotation (Figure 3-4). Among the practices, conservation tillage had the largest impact, and the levels of sequestration associated with this practice tended to be larger after 2000. In contrast, bare summer fallow management

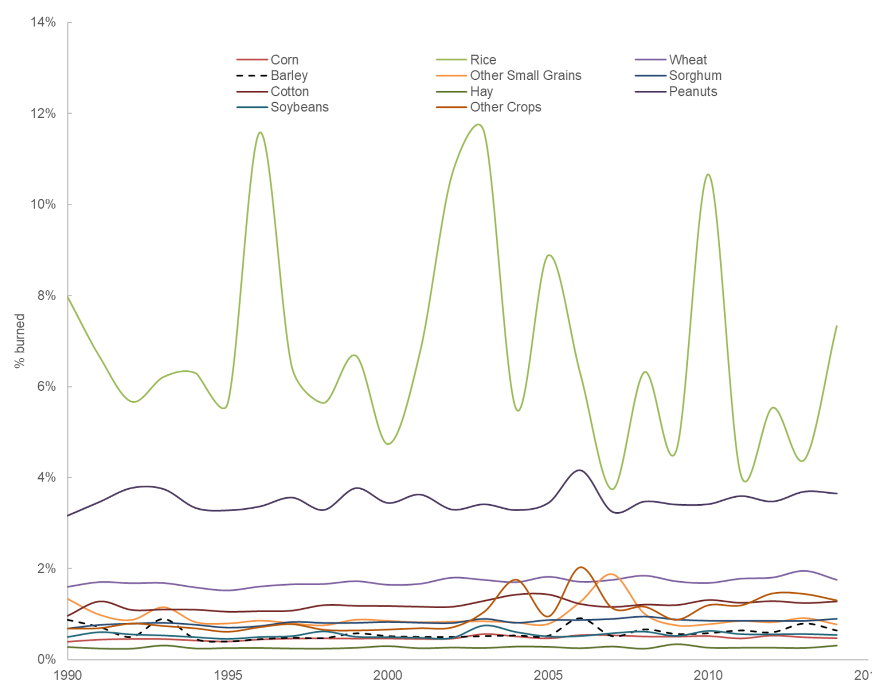


Figure 3-3b Percentage of Crop Production Area With Residue Burning Management, 1990–2014

[4] Emissions and sinks of carbon in agricultural soils are expressed in terms of CO_2 equivalents; carbon sequestration is a result of changes in stocks of carbon in soils, from which CO_2 fluxes are inferred. Units of CO_2 equivalent can be converted to carbon using a multiplier of 0.272.

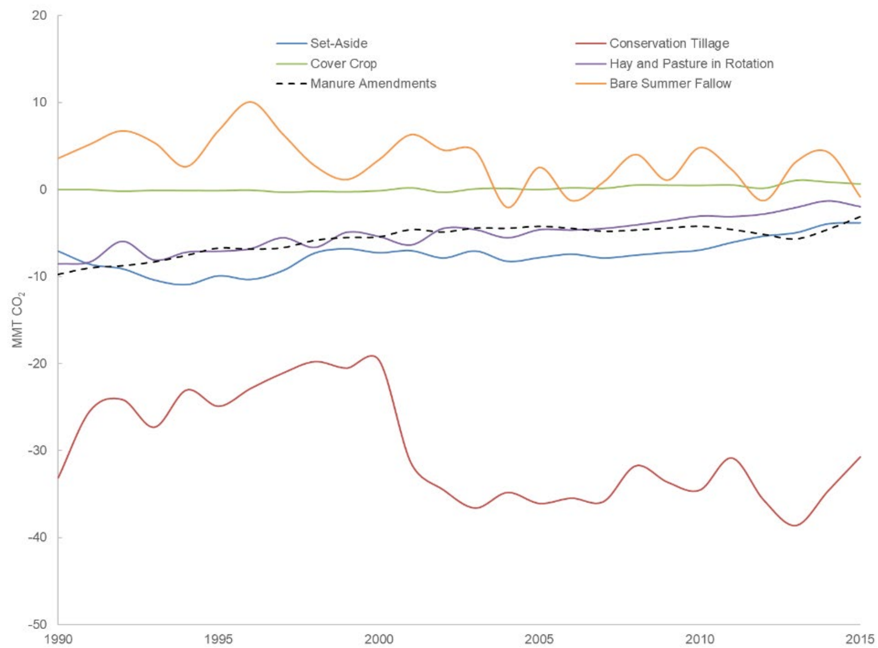


Figure 3-4 Impact of Key Management Practices on Soil Organic Carbon Stock Changes, 1990–2015
(Million metric tons CO2 eq. yr-1is metric tons carbon dioxide equivalent per year.)

led to a decrease in soil organic carbon across the entire time series. Planting winter cover crops did not significantly impact soil organic carbon in the GHG inventory analysis, but it was assumed that cover crops were terminated with tillage management in this analysis. If cover crops are terminated with herbicide applications, then there is a significant increase in soil organic carbon based on a separate analysis using the inventory framework with DayCent model simulations. Additional activity data collection is needed to determine the termination practices for cover crops across the United States.

In contrast to mineral soils which stored carbon, the small area of cultivated organic soils, i.e., Histosols (less than 1 million hectares), was a net source of CO_2 emissions for all years in the inventory (1990–2018).

In 2018, about 37 MMT CO_2 eq. was emitted from cultivation of these soils (Table 3-1). Liming of agricultural soils resulted in emissions of about 3 MMT CO_2 eq. in 2018, and urea fertilization contributed an additional 5 MMT CO_2 eq. of emissions in 2018. Total net carbon sequestration in 2018 equaled about 2 MMT CO_2 eq. when all of the above components were taken into consideration. Carbon uptake on agricultural soils varied between 1990 and 2018 (Table 3-7), driven largely by management changes and weather fluctuations.

Many regions in the Corn Belt, Great Plains, and Eastern United States are storing C in cropland mineral soils due to adoption of conservation tillage, manure amendments, and other practices (Map 3-3a). For example, soils managed with conservation tillage stored about 30.7 MT CO_2 eq. in 2015. In contrast, emissions from cultivation of organic soils (i.e., Histosols) were highest in the Southeast along the Gulf and Atlantic Coasts and Upper Great Lakes region, along with a concentrated area in the northern Central Valley of California and widely distributed areas of emissions in the Mid-Atlantic and New England (Figure 3-3b).

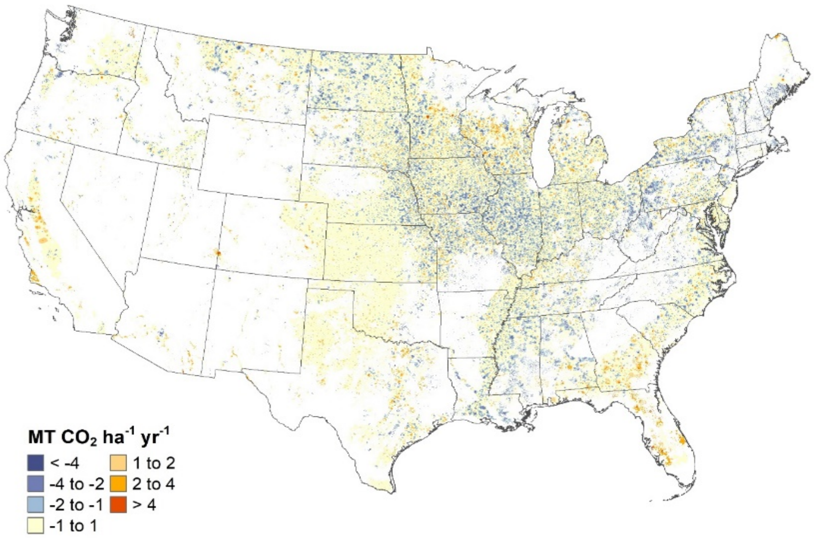
State-level data are provided in Appendix B with information about management activity and associated soil carbon changes. Appendix Table B-5 provides information on the area of croplands with mineral and organic soils, in addition to the amount of carbonate lime and urea fertilization occurring in each State. Appendix Table B-6 provides the soil carbon changes for mineral and organic soils in croplands, and the emissions from carbonate lime amendments and urea fertilization. Appendix Table B-11 provides State-level estimates of soil organic carbon stock changes in mineral soils for cropland management systems.

3.6.1 Methods for Estimating Carbon Stock Changes in Agricultural Soils

Two broad categories of cropland were considered: cropland remaining cropland and land converted to cropland. Within both categories, Tier 2 and Tier 3 methodologies were used to estimate soil organic carbon changes. The Tier 2 approach is based on relatively simple equations provided by the IPCC (2006) that has been modified to better represent conditions in the United States (Ogle et al. 2003). The Tier 3 approach uses the more complex DayCent ecosystem model to simulate carbon dynamics and CO_2 emissions and removals for croplands. Both tiers rely on land use and management data based primarily on the USDA National Resources Inventory (NRI) (USDA 2018a) along with management data products derived from several surveys, including USDA Conservation Effects and Assessment Project (CEAP), Agricultural Resource Management Surveys

Map 3-3a Soil Organic Carbon Stock Changes for Cropland on Mineral Soils, 2015

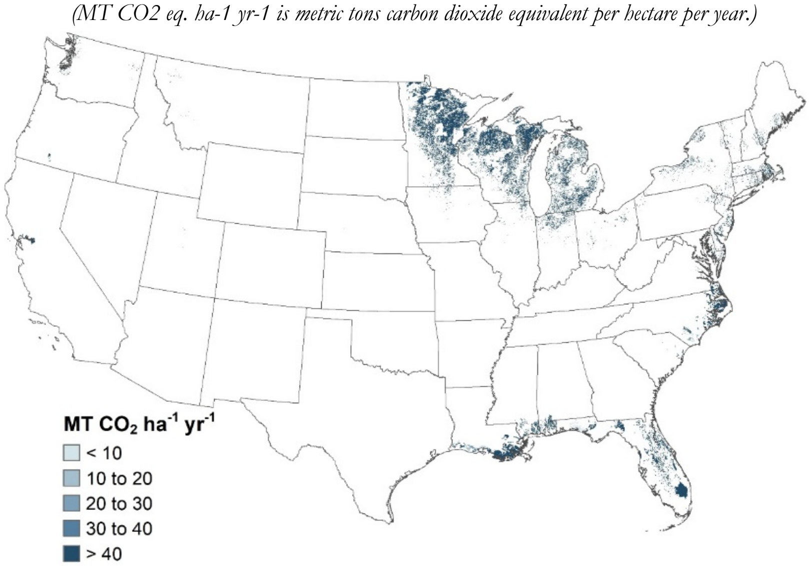
(MT CO2 eq. ha-1 yr-1 is metric tons carbon dioxide equivalent per hectare per year.)



Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. Areas with a value of < 0 are a net sink of CO_2 eq. emissions. This map is reprinted from EPA (2020).

Map 3-3b Soil Organic Carbon Stock Changes for Cropland on Organic Soils, 2015

(MT CO2 eq. ha-1 yr-1 is metric tons carbon dioxide equivalent per hectare per year.)



Note: Emissions data are based on land areas estimated with the Tier 2 method provided in IPCC (2006), with country-specific C loss rates (Ogle et al. 2003). This map is reprinted from EPA (2020).

(ARMS), Conservation Technology Information Center (CTIC) surveys, USDA Census of Agriculture, and EPA Manure Management dataset using machine learning methods (See Section 3.3.2.3 for more information). The NRI represents a robust statistical sampling of land use and management on all non-Federal land in the United States, and 349,464 NRI survey points occurred in agricultural lands and were used in the inventory analysis.

The methodology description below provides a brief summary of the models and datasets, but additional details are given in Section 3.3.2. Refer to EPA (2020) for a complete description of the methodologies used to estimate soil organic carbon changes, as well as methods for estimating CO_2 emissions from liming additions to soils and urea fertilization.

3.6.2 Tier 3 DayCent Model Simulations for Most Cropland Mineral Soils

In this section, we highlight aspects of the DayCent model relevant to estimating changes in soil organic C stocks beyond the simulation descriptions in Section 3.3.2. Soil organic carbon stock change estimates from DayCent reflect the balance between carbon additions from crop residues that are not removed during harvest and manure amendments and carbon losses from decomposition of crop residues and soil organic matter. Soil organic matter is modeled in DayCent as three pools, referred to as active, slow, and passive, which have turnover times ranging from a few years in the active pool to decades in the slow pool and centuries in the passive pool (Parton et al. 1987). The turnover times reflect the impact of temperature, moisture and decomposability of soil organic matter in the pool by soil microbial organisms, including bacteria and fungi.

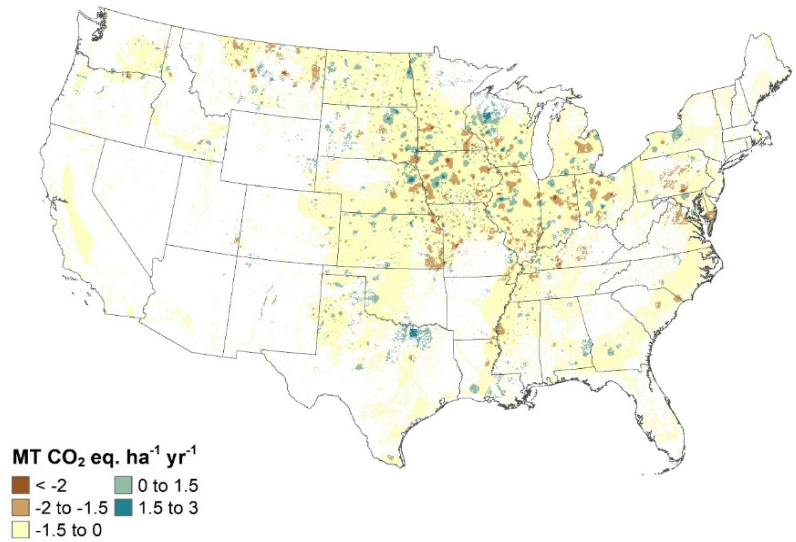
Soil organic carbon stock changes that are estimated by DayCent were compared with measurements from 92 long-term field experiments with over 900 measurements of soil organic carbon. A linear-mixed effect modeling approach was applied to statistically evaluate the prediction error associated with the DayCent model and quantify the bias and precision in the resulting estimates (Ogle et al. 2007). Over 80 percent of the uncertainty in the DayCent model estimates of soil organic carbon stock changes is associated with model structure and parameterization (Ogle et al. 2010). Note that the model does not account for carbon losses from erosion nor gains from deposition of eroded sediment, which contributes to the overall uncertainty in soil organic carbon estimates.

3.6.3 Tier 1 and 2 Approaches for Remaining Cropland Mineral Soils, Organic Soils, Urea Application, and Liming

A Tier 2 approach was used to estimate soil organic carbon stock changes for crop rotations that are not simulated by the DayCent model, for non-agricultural lands that were converted to cropland, such as forestland, and for estimating carbon losses from cultivated organic soils (i.e., Histosols). Data on climate, soil type, and land use were used to classify land area and apply appropriate stock change factors. Carbon stock change factors that are specific to conditions in the United States were derived from published literature to estimate the impact of management practices (e.g., changes in tillage or crop rotation) on soil carbon fluxes (Ogle et al. 2003, 2006).

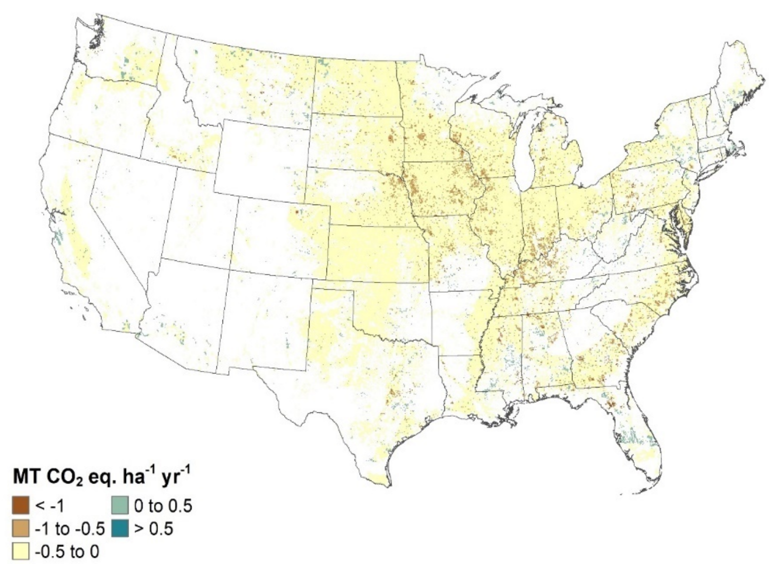
Stock change factors and reference carbon stocks can vary for different climate regimes and soil types. The IPCC method defines eight climate types according to mean annual temperature, precipitation, and potential evapotranspiration. Six of these occur in the conterminous United States and Hawaii. The climates were mapped for the United States using climate data from the WorldClim data set (Hijmans et al. 2005) and potential evapotranspiration data from the Consortium for Spatial Information (CGIAR-CSI) (Zomer et al. 2008; Zomer et al. 2007). Reference soil carbon stocks were stratified by climate region and categorized into six major groupings, based on taxonomic orders that relate to soil development and physical characteristics that influence soil carbon contents. Estimates for carbon stocks under conventionally managed cropland (defined as the reference land use) were derived from the National Soil Survey Characterization Database (USDA 1997b).

Map 3-3c Impact of Management Practices on Soil Organic Carbon Stock Changes in 2015 for Conservation Reserve Program (Set-Aside)
(MT CO2 eq. ha-1 yr-1 is metric tons carbon dioxide equivalent per hectare per year.)



Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. Areas with a value of < 0 are a net sink of CO_2 eq. emissions.

Map 3-3d Impact of Management Practices on Soil Organic Carbon Stock Changes in 2015 for Conservation Tillage
(MT CO2 eq. ha-1 yr-1 is metric tons carbon dioxide equivalent per hectare per year.)

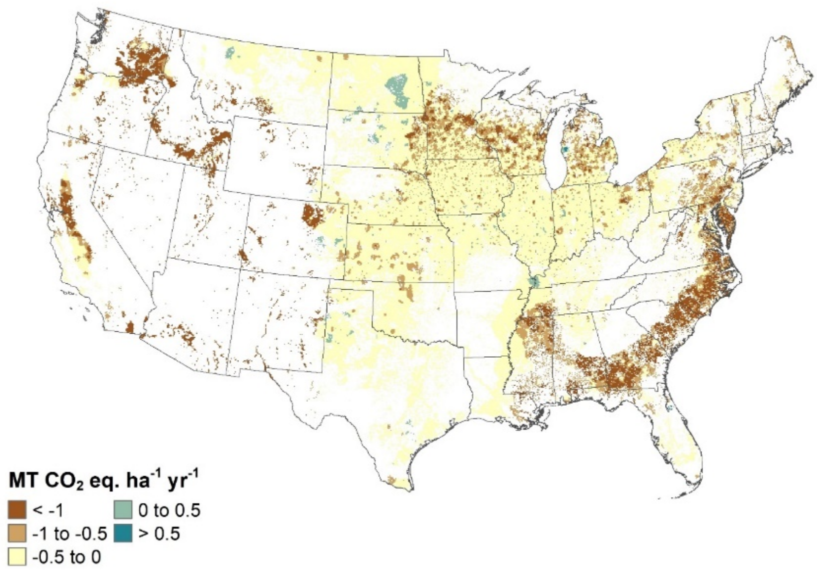


Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. Areas with a value of < 0 are a net sink of CO_2 eq. emissions.

Based on the NRI, crop management systems were aggregated into 22 different categories. Tillage practices are based on a combination of data from Conservation Effects Assessment Project (CEAP) (USDA 2006) and Conservation Technology Information Center (CTIC 1998) (See Section 3.3.2.3 for more information). Data for wetland restoration under CRP were obtained from Euliss and Gleason (2002). Organic soils (i.e., peat, mucks) that have been

Map 3-3e Impact of Management Practices on Soil Organic Carbon Stock Changes in 2015 for Manure Amendments

(MT CO2 eq. ha-1 yr-1 is metric tons carbon dioxide equivalent per hectare per year.)



Note: Emissions data are based on land areas estimated with the Tier 3 method. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method. Areas with a value of < 0 are a net sink of CO_2 eq. emissions.

drained and converted to cropland or pasture are subject to potentially high rates of carbon loss. Annual carbon losses were estimated using IPCC (2006) methodology except that carbon loss rates were used in the calculations that are specific to conditions in the United States instead of the default IPCC rates (Ogle et al. 2003). Manure nitrogen amendments over the inventory time period were based on application rates and areas amended with manure nitrogen derived from CEAP data and the EPA manure management data (EPA 2020) (See Section 3.3.2.3 for more information).

Carbon dioxide emissions from the application of urea fertilizers to agricultural soils were estimated using the IPCC (2006) Tier 1 methodology which assumes the CO_2 fixed during the industrial process for urea production is released after application. The annual amounts of urea applied (TVA 1991, 1992, 1993, 1994; AAPFCO 1995 through 2017) were multiplied by the Tier 1 emission factor of 0.20 tons CO_2-C/ton of urea.

Limestone and dolomite are often applied to acidic soils to raise the pH. However, CO_2 is emitted when these carbonate-rich materials degrade. Emissions were estimated using a Tier 2 approach. Application rates were derived from estimates and industry sources (Minerals Yearbook, published by the United States Bureau of Mines through 1994 and by the United States Geological Survey from 1994 to present). The emission factors used, 0.059 tons CO_2-C/ton of limestone and 0.064 tons CO_2-C/ton of dolomite, are lower than the default IPCC emission factors because they account for a portion of limestone that may leach through soils and be transported through waterways to the ocean (West & McBride 2005). The methodology summarized above is described in more detail in National GHG Inventory report (EPA 2020).

3.6.4 Uncertainty in Estimating Carbon Stock Changes in Agricultural Soils

Uncertainty was estimated for all of the components included in the inventory for soil CO_2 fluxes. Uncertainty was combined for soil organic carbon stock changes on mineral soils for croplands simulated by DayCent, mineral soils for cropland that are not estimated with DayCent, cropland organic soils, and emissions from liming and urea applications to soils. Section 3.3.2.2 describes uncertainty for cropland that was simulated using DayCent. Uncertainty for the remaining sources was estimated using simple error propagation (IPCC 2006). Simple error propagation combines uncertainties in the emission factors and activity data by taking the square root of the sum of the squares of the standard deviations of the components. The 95-percent confidence interval ranged from -93 to 89 MMT CO_2 eq. for the estimated total net soil CO_2 removal of -2 MMT CO_2 eq. in 2018 (Table 3-1).

3.6.5 Changes Compared to the 4th Edition of the USDA GHG Report

The main changes from the 4th edition of this report are discussed in Section 3.3.4. The most important of these changes for soil organic carbon was to develop a new management data product that combines ARMS, CTIC, Agricultural Census, and the EPA manure management data using machine learning methods. Another key improvement was the reparameterization of the soil organic submodel in DayCent to 30 cm using Bayesian calibration methods (Gurung et al. 2020). These changes resulted in a decrease in soil organic carbon storage of approximately 3 MMT CO_2 per year on average.

3.7 Planned Improvements

In order to improve the ability of the United States to track progress made towards its commitments under the Paris Agreement, the timeliness of the agricultural sector estimates in the national GHG inventory must be improved so that it reflects annual changes in on-farm management to demonstrate the benefits of increased adoption of conservation activities. This will require investments to improve existing surveys to fill activity data gaps, improving data connectivity and interoperability between current survey instruments, and better utilizing industry data to determine adoption rates of emerging technologies (e.g. biochar, enhanced efficiency fertilizers). USDA is establishing a GHG Inventory and Assessment Program within the Office of the Chief Economist to carry out this work.

There are also several updates to the methodologies used to calculate emissions reported in the annual inventory complied by the EPA as well as subsequent editions of this report that are under development for estimating GHG emissions from croplands. Improvements to the DayCent crop phenology submodel are anticipated to better represent senescence, particularly following grain filling in crops, which in turn, will improve modeling of carbon inputs in residues to the soil organic matter pools. In addition, Bayesian calibration methods will be applied to other submodels in DayCent, besides the soil organic matter submodel that was recently calibrated (Gurung et al. 2020). It is anticipated that calibration will reduce uncertainty in DayCent estimates of greenhouse gas emissions and soil organic carbon changes. The number of experimental study sites used for testing will be expanded to more accurately assess model structural uncertainty. For soil N2O, studies measuring daily N2O fluxes will be given high priority because they provide more robust estimates of annual emissions than do studies that measure emissions less frequently.

Another planned improvement is to account for the use of slow-release fertilizers and nitrification inhibitors with collection of activity data for these practices. Field investigations suggest that the use of these types of nitrogen fertilizers reduce the rate of N2O emissions, but there are no activity data collected for these practices at the national scale.

In addition, there is a mismatch between the amount of residue burning that is included in DayCent model simulations for estimating soil organic carbon change and soil N2O emissions relative to the residue burned according to the Field Burning of Agricultural Residues source category (EPA 2020). Consequently, there is an effort to simulate residue burning with DayCent using the data from the Field Burning of Agricultural Residues source category.

Hawaii and Alaska are not currently included in the inventory for agricultural soil management, except for N_2O emissions from drained organic soils (i.e., Histosols) in Hawaii. In addition to more fully incorporating Alaska and Hawaii in the inventory, it is also expected that more crop types will be tested and added into the DayCent model simulations for the Tier 3 method, and removed from the Tier 1 and 2 analyses for soil N_2O and soil organic carbon, respectively.

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3.9 Appendix B

B-1 State-Level Annual Nitrogen Inputs to Cropland Soils, 1990, 1995, 2000, 2005, 2010, 2013–2015.

B-2 State-Level Soil Nitrous Oxide Emissions from Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015.

B-3 State-Level Cropland Areas With Residue Burning Management and Rice Cultivation (Rice Harvested Areas in Parentheses), 1990, 1995, 2000, 2005, 2010, 2013–2015.

B-4 State-Level Methane Emissions from Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015

B-5 State-Level Cropland Area With Mineral and Organic Soils, and Total Amount of Carbonate Lime[1] and Urea Fertilizer Applied to Cropland Soils, 1990, 1995, 2000, 2005, 2010, 2013–2015

B-6 State-Level Soil Carbon Change for Mineral Soils and Organic Soils, in addition to Carbonate Lime[1] and Urea Applications to Cropland Agriculture by State, 1990, 1995, 2000, 2005, 2010, 2013–2015.

B-7 State-Level Areas by Cropland Systems, 1990, 1995, 2000, 2005, 2013–2015.

B-8 State-Level Estimates by Cropland Systems of Total Annual Direct Nitrous Oxide Emissions, 1990, 1995, 2000, 2005, 2013–2015

B-9 State-Level Estimates by Cropland Systems of Total Annual Indirect Nitrous Oxide Emissions From Volatilization, 1990, 1995, 2000, 2005, 2013–2015

B-10 State-Level Estimates by Cropland Systems of Total Annual Indirect Nitrous Oxide Emissions from Nitrogen Leaching/Runoff, 1990, 1995, 2000, 2005, 2010, 2013–2015.

B-11 State-Level Estimates by Cropland Management Systems of Annual Soil Organic Carbon Stock Changes, 1990, 1995, 2000, 2005, 2010, 2013–2015

B-12 National and State-Level Area of Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015

Appendix Table B-1 State-Level Annual Nitrogen Inputs to Cropland Soils, 1990, 1995, 2000, 2005, 2010, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Sources	*Gg N*							
Alabama	**205.7**	**221.0**	**215.4**	**227.9**	**205.8**	**254.6**	**242.0**	**228.3**
Synthetic Fertilizer	63.96	68.2	73.4	78.2	69.8	72.9	78.8	63.9
Residue N / Biological N fixation	40.19	41.0	43.9	46.2	44.6	51.3	49.4	38.4
Managed Manure	12.72	12.2	11.3	7.3	6.6	7.9	10.7	4.4
Other Organic N Inputs	0	0.0	0.4	0.9	0.2	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	88.84	99.6	86.4	95.2	84.6	122.5	103.0	121.6
Arizona	**35.07**	**42.9**	**36.9**	**42.4**	**41.5**	**60.7**	**54.3**	**49.5**
Synthetic Fertilizer	16.17	16.1	13.7	15.2	13.5	18.0	16.0	11.5
Residue N / Biological N fixation	5.206	6.3	4.8	5.6	5.0	4.8	4.6	5.4
Managed Manure	1.163	2.5	2.8	2.3	1.9	11.8	7.3	5.3
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	12.54	18.0	15.7	19.3	21.2	26.1	26.4	27.4
Arkansas	**687.3**	**710.5**	**711.4**	**616.9**	**666.6**	**671.2**	**707.8**	**715.6**
Synthetic Fertilizer	266.7	294.9	323.3	256.4	286.4	257.7	264.2	261.4
Residue N / Biological N fixation	99.07	116.5	93.1	103.9	108.1	95.9	101.6	96.9
Managed Manure	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Organic N Inputs	0	0.1	0.0	0.1	0.1	0.0	0.1	0.0
Mineralization & Asymbiotic Fixation	321.6	299.1	295.1	256.4	271.9	317.6	341.9	357.2
California	**240.9**	**249.6**	**233.9**	**218.8**	**202.2**	**223.4**	**206.9**	**196.1**
Synthetic Fertilizer	106.8	100.0	86.3	83.5	80.2	89.1	78.0	64.4
Residue N / Biological N fixation	48.72	45.4	47.0	41.6	33.0	44.7	36.1	37.5
Managed Manure	6.58	8.5	6.4	5.5	5.6	9.6	7.3	4.0
Other Organic N Inputs	0.008	0.1	0.0	0.0	0.1	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	78.85	95.7	94.2	88.2	83.2	80.1	85.5	90.2
Colorado	**462.2**	**523.9**	**454.9**	**453.4**	**465.3**	**452.1**	**454.1**	**434.8**
Synthetic Fertilizer	165.6	162.3	187.4	131.3	143.8	156.6	144.7	120.7
Residue N / Biological N fixation	108.8	140.3	128.1	118.3	127.1	92.9	94.0	105.5
Managed Manure	10.77	10.3	11.3	6.5	15.0	8.5	8.3	7.9
Other Organic N Inputs	0	0.0	0.1	0.1	0.6	0.0	0.1	0.0
Mineralization & Asymbiotic Fixation	177.1	210.9	128.1	197.3	178.7	194.1	207.0	200.7
Connecticut	**19.24**	**19.4**	**21.2**	**18.6**	**19.4**	**21.5**	**17.4**	**16.1**
Synthetic Fertilizer	3.975	5.7	4.6	3.8	3.8	5.8	2.5	2.5
Residue N / Biological N fixation	5.615	6.0	5.7	5.5	5.8	5.3	5.6	5.4
Managed Manure	1.772	1.6	1.5	1.6	1.7	1.2	1.1	0.9
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	7.879	6.1	9.4	7.7	8.1	9.1	8.2	7.3
Delaware	**30.91**	**29.8**	**35.7**	**30.9**	**31.3**	**34.2**	**33.3**	**29.0**
Synthetic Fertilizer	8.058	8.0	10.5	9.9	10.1	11.9	11.6	8.2

Residue N / Biological N fixation	4.42	4.4	4.7	4.4	4.4	3.7	4.0	3.9
Managed Manure	3.8	4.2	5.2	4.2	4.5	4.6	5.2	3.3
Other Organic N Inputs	0.066	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	14.57	13.1	15.2	12.3	12.3	14.0	12.5	13.6
Florida	**37.22**	**34.9**	**38.2**	**39.3**	**47.5**	**54.5**	**52.5**	**44.9**
Synthetic Fertilizer	13.32	14.1	16.8	13.4	18.5	20.4	20.8	12.6
Residue N / Biological N fixation	5.903	4.5	6.0	5.4	8.5	7.7	7.9	5.6
Managed Manure	1.925	1.9	1.3	0.4	0.8	1.8	0.8	0.4
Other Organic N Inputs	0.034	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	16.04	14.3	14.1	20.1	19.7	24.6	23.1	26.3
Georgia	**284.3**	**272.6**	**307.5**	**303.5**	**302.0**	**330.1**	**290.6**	**286.0**
Synthetic Fertilizer	89.42	98.5	123.6	121.4	130.8	132.9	110.6	106.9
Residue N / Biological N fixation	44.34	37.4	49.7	45.9	46.0	46.4	47.4	32.5
Managed Manure	26.37	13.3	15.8	13.5	11.9	17.7	10.7	8.3
Other Organic N Inputs	0.266	0.1	0.1	1.1	0.2	0.1	0.1	0.0
Mineralization & Asymbiotic Fixation	123.9	123.3	118.4	121.5	113.2	133.0	121.7	138.4
Idaho	**333.3**	**351.2**	**334.5**	**327.1**	**334.0**	**333.5**	**342.7**	**296.6**
Synthetic Fertilizer	150.1	155.4	146.8	135.1	144.1	149.9	145.7	101.6
Residue N / Biological N fixation	89.81	92.4	87.4	85.7	79.2	73.6	64.8	68.7
Managed Manure	9.828	6.9	12.8	9.0	19.0	17.8	18.5	15.6
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	83.53	96.5	87.4	97.3	91.7	92.1	113.6	110.7
Illinois	**2,357**	**2,329.8**	**2,485.4**	**2,087.1**	**2,534.2**	**2,614.6**	**2,821.3**	**2,824.6**
Synthetic Fertilizer	925.3	906.6	931.2	947.2	853.0	1,074.6	1,148.0	1,113.6
Residue N / Biological N fixation	396.7	459.3	502.6	419.3	547.5	520.0	549.0	493.1
Managed Manure	42.11	40.5	38.3	41.3	42.2	41.8	43.8	38.0
Other Organic N Inputs	0.228	0.1	0.2	0.6	0.7	0.6	0.2	0.0
Mineralization & Asymbiotic Fixation	993.1	923.4	1,013.1	678.6	1,090.8	977.5	1,080.3	1,179.9
Indiana	**1,357**	**1,297.4**	**1,443.4**	**1,372.7**	**1,611.3**	**1,540.9**	**1,536.5**	**1,481.9**
Synthetic Fertilizer	583.6	508.8	502.1	584.8	620.4	595.5	623.2	521.1
Residue N / Biological N fixation	222.4	261.2	276.0	253.4	371.0	286.1	291.8	278.0
Managed Manure	23.72	26.0	24.2	25.5	25.6	26.1	26.4	21.6
Other Organic N Inputs	1.095	1.4	0.2	0.4	0.2	0.2	0.2	0.0
Mineralization & Asymbiotic Fixation	526.3	500.1	640.8	508.5	594.1	633.0	594.8	661.3
Iowa	**2,867**	**2,629.0**	**2,790.5**	**2,967.1**	**3,206.2**	**2,984.6**	**3,319.8**	**3,048.2**
Synthetic Fertilizer	984.4	915.8	1,043.8	1073.4	1,056.2	1,240.7	1,213.9	1,001.5
Residue N / Biological N fixation	574.4	594.6	660.0	682.2	675.3	636.7	679.8	615.3
Managed Manure	88.97	86.1	87.5	89.1	92.7	91.1	90.3	74.5
Other Organic N Inputs	2.313	3.5	0.3	1.3	0.3	0.8	0.5	0.0
Mineralization & Asymbiotic Fixation	1,217	1,029.0	998.8	1,121.0	1,381.7	1,015.2	1,335.3	1,356.9
Kansas	**1,401**	**1,622.3**	**1,565.9**	**1,771.1**	**1,882.4**	**1,763.9**	**1,699.0**	**1,732.8**
Synthetic Fertilizer	599.8	688.7	804.2	751.3	828.8	732.3	633.9	568.9
Residue N / Biological N fixation	241.8	300.7	270.1	290.2	333.4	260.6	263.7	277.9
Managed Manure	19.34	20.8	25.8	26.9	32.9	28.8	28.8	19.1
Other Organic N Inputs	0.049	0.0	0.2	1.3	0.3	0.4	0.0	0.0
Mineralization & Asymbiotic Fixation	539.8	612.0	465.6	701.3	686.9	741.9	772.6	866.9

Kentucky	**531.1**	**591.6**	**649.9**	**603.6**	**622.6**	**727.7**	**684.6**	**719.5**
Synthetic Fertilizer	185.6	187.2	202.0	193.9	190.1	218.3	226.3	206.3
Residue N / Biological N fixation	108.1	122.0	131.2	136.5	157.6	142.6	140.0	139.8
Managed Manure	13	13.6	14.2	14.6	18.6	19.5	19.6	15.4
Other Organic N Inputs	1.108	1.2	0.7	1.3	0.6	0.7	0.2	0.0
Mineralization & Asymbiotic Fixation	223.3	267.6	301.7	257.5	255.8	346.6	298.5	358.0
Louisiana	**431.7**	**415.1**	**435.9**	**408.3**	**419.0**	**462.3**	**441.5**	**474.6**
Synthetic Fertilizer	181.1	175.6	202.4	201.8	194.2	192.5	150.1	179.3
Residue N / Biological N fixation	60.43	60.2	62.3	63.1	60.6	63.2	69.6	59.8
Managed Manure	0.885	1.2	1.2	0.5	0.5	0.4	0.7	0.0
Other Organic N Inputs	1.09	0.0	0.0	1.8	0.6	0.1	0.1	0.0
Mineralization & Asymbiotic Fixation	188.2	178.1	169.9	141.1	163.1	206.2	221.1	235.5
Maine	**48.1**	**43.1**	**47.2**	**57.2**	**55.9**	**42.4**	**37.2**	**38.7**
Synthetic Fertilizer	11.55	11.6	13.0	22.0	21.5	9.1	5.7	6.9
Residue N / Biological N fixation	16.84	17.3	17.3	16.6	15.1	14.0	15.3	14.8
Managed Manure	0.367	0.7	0.3	0.4	0.5	0.7	0.5	0.2
Other Organic N Inputs	0.021	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	19.32	13.4	16.6	18.3	18.9	18.5	15.7	16.8
Maryland	**164**	**164.1**	**175.7**	**156.8**	**143.9**	**169.2**	**169.9**	**148.8**
Synthetic Fertilizer	42.71	46.5	45.7	42.7	26.8	39.4	37.8	23.9
Residue N / Biological N fixation	25.09	27.4	29.6	32.0	30.4	32.9	33.7	30.8
Managed Manure	25.78	23.0	19.8	16.8	20.4	19.5	19.2	15.3
Other Organic N Inputs	0.018	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	70.45	67.2	80.6	65.2	66.3	77.4	79.1	78.9
Massachusetts	**24.64**	**26.3**	**26.1**	**26.5**	**24.0**	**25.8**	**24.0**	**25.6**
Synthetic Fertilizer	8.19	10.5	6.9	10.0	8.1	8.7	7.5	9.1
Residue N / Biological N fixation	6.357	7.9	7.2	6.9	7.2	7.0	7.1	6.7
Managed Manure	1.374	0.8	0.5	0.5	0.5	0.2	0.2	0.4
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	8.718	7.1	11.4	9.0	8.3	9.9	9.2	9.5
Michigan	**727.3**	**713.1**	**767.9**	**677.8**	**732.3**	**744.0**	**747.3**	**700.7**
Synthetic Fertilizer	247.2	231.7	213.3	212.9	195.6	229.3	232.4	164.4
Residue N / Biological N fixation	152.1	167.4	164.1	159.7	179.7	166.1	168.9	170.0
Managed Manure	32.45	33.7	28.9	29.2	28.2	35.5	30.7	25.4
Other Organic N Inputs	0.136	0.2	0.2	0.1	0.1	0.1	0.1	0.0
Mineralization & Asymbiotic Fixation	295.5	280.1	361.4	275.9	328.6	313.0	315.3	340.8
Minnesota	**1,963**	**1,928.4**	**1,908.6**	**2,034.0**	**2,192.6**	**1,985.7**	**2,121.9**	**1,986.9**
Synthetic Fertilizer	605.6	590.6	592.7	587.4	623.0	658.7	660.3	512.8
Residue N / Biological N fixation	431.2	408.7	442.2	417.1	481.0	449.7	450.5	461.4
Managed Manure	135.8	126.9	126.5	125.0	123.5	142.8	137.9	112.1
Other Organic N Inputs	0.55	0.3	0.4	0.5	0.0	0.2	0.2	0.0
Mineralization & Asymbiotic Fixation	789.3	801.9	746.9	903.9	965.0	734.3	873.0	900.6
Mississippi	**466.3**	**456.6**	**453.5**	**399.8**	**425.0**	**468.7**	**504.8**	**459.7**
Synthetic Fertilizer	199.6	168.8	169.3	126.3	113.7	115.5	113.6	111.2
Residue N / Biological N fixation	80.78	99.7	95.6	94.2	98.4	96.6	105.0	86.2
Managed Manure	2.813	2.2	2.0	2.5	2.7	2.4	1.9	2.4
Other Organic N Inputs	0.553	0.1	0.1	0.1	0.1	1.0	0.8	0.0

Mineralization & Asymbiotic Fixation	182.6	185.8	186.6	176.8	210.1	253.3	283.6	260.0
Missouri	**1,288**	**1,370.6**	**1,440.1**	**1,375.1**	**1,578.2**	**1,523.8**	**1,694.9**	**1,666.6**
Synthetic Fertilizer	405.8	378.4	467.8	472.3	459.5	492.5	503.0	488.8
Residue N / Biological N fixation	258.7	313.3	276.6	274.2	337.1	322.0	363.9	318.6
Managed Manure	16.02	13.1	12.7	15.2	15.0	15.2	13.4	11.9
Other Organic N Inputs	1.377	1.3	0.2	0.7	0.1	1.0	0.6	0.0
Mineralization & Asymbiotic Fixation	606	664.5	682.8	612.7	766.5	693.1	814.0	847.3
Montana	**688.6**	**817.5**	**836.9**	**801.1**	**916.3**	**934.9**	**879.5**	**806.0**
Synthetic Fertilizer	100.5	147.2	193.0	120.2	173.3	221.1	252.5	241.2
Residue N / Biological N fixation	264.3	290.6	297.8	317.6	294.2	274.6	257.3	231.9
Managed Manure	4.218	2.5	5.4	2.4	3.3	5.8	6.2	4.7
Other Organic N Inputs	0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
Mineralization & Asymbiotic Fixation	319.6	377.1	340.7	360.7	445.4	433.4	363.2	328.2
Nebraska	**1,589**	**1,616.8**	**1,668.8**	**1,946.8**	**2,110.5**	**1,945.1**	**2,071.7**	**1,963.5**
Synthetic Fertilizer	753.5	745.3	806.1	819.4	885.8	924.7	848.9	773.0
Residue N / Biological N fixation	326.1	330.7	343.5	397.0	417.9	365.5	402.5	350.4
Managed Manure	44.98	42.7	47.5	48.8	50.4	48.8	50.9	44.1
Other Organic N Inputs	0.033	0.1	0.1	0.3	0.3	0.3	0.0	0.0
Mineralization & Asymbiotic Fixation	464.4	498.0	471.5	681.2	756.2	605.8	769.4	796.0
Nevada	**31.25**	**30.6**	**30.5**	**30.4**	**27.2**	**26.8**	**28.6**	**29.6**
Synthetic Fertilizer	3.002	0.5	2.2	3.0	1.9	2.7	1.6	1.7
Residue N / Biological N fixation	15.2	15.8	14.5	12.7	9.7	11.6	10.2	9.1
Managed Manure	0.014	0.0	0.0	0.8	0.3	1.5	0.6	2.3
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	13.04	14.2	13.8	13.9	15.4	11.0	16.2	16.5
New Hampshire	**15.72**	**13.0**	**14.4**	**17.1**	**15.7**	**14.8**	**14.1**	**14.5**
Synthetic Fertilizer	3.56	2.3	1.4	2.8	3.5	1.3	0.9	1.5
Residue N / Biological N fixation	5.747	6.0	6.2	5.9	5.8	5.5	6.0	5.8
Managed Manure	0.458	0.4	0.4	0.3	0.4	0.3	0.4	0.4
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	5.954	4.3	6.4	8.1	6.0	7.6	6.9	6.8
New Jersey	**38.83**	**37.8**	**42.1**	**34.2**	**34.3**	**37.5**	**34.9**	**35.6**
Synthetic Fertilizer	9.983	11.1	11.4	9.9	8.9	10.1	9.0	9.1
Residue N / Biological N fixation	8.626	9.0	8.9	8.4	8.6	8.5	9.0	8.9
Managed Manure	4.025	4.3	3.5	2.6	2.2	2.0	2.0	2.1
Other Organic N Inputs	0.036	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	16.16	13.5	18.3	13.3	14.6	16.8	15.0	15.5
New Mexico	**110.9**	**102.6**	**98.9**	**96.5**	**89.6**	**81.3**	**80.5**	**84.7**
Synthetic Fertilizer	40.76	37.1	32.9	27.3	25.0	19.2	20.0	19.7
Residue N / Biological N fixation	21.41	23.8	26.3	25.0	19.7	17.2	16.6	15.8
Managed Manure	6.18	2.8	3.5	3.8	4.0	6.6	3.8	5.3
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	42.54	38.9	36.2	40.4	40.9	38.3	40.0	43.9
New York	**482.8**	**449.9**	**529.5**	**481.4**	**523.9**	**552.3**	**531.5**	**529.2**
Synthetic Fertilizer	85.5	88.2	63.7	71.2	71.2	100.6	100.6	100.3
Residue N / Biological N fixation	132.5	138.7	150.1	139.9	140.3	136.4	139.9	137.0

Managed Manure	26.3	24.5	22.9	22.7	30.5	28.6	26.2	25.8
Other Organic N Inputs	0.017	0.1	0.0	0.5	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	238.6	198.6	292.8	247.0	281.9	286.7	264.8	266.1
North Carolina	**399.5**	**411.1**	**426.1**	**386.7**	**402.3**	**446.3**	**417.7**	**374.0**
Synthetic Fertilizer	133.5	146.3	149.8	125.6	148.2	163.4	146.1	116.1
Residue N / Biological N fixation	72.3	64.8	85.2	85.1	80.5	79.7	80.7	66.9
Managed Manure	38.06	30.5	26.1	22.0	25.2	35.0	25.7	17.4
Other Organic N Inputs	0	0.2	0.3	0.6	0.3	0.2	0.1	0.0
Mineralization & Asymbiotic Fixation	155.6	169.2	164.7	153.4	148.1	168.0	165.0	173.7
North Dakota	**914.6**	**1,148.8**	**1,094.6**	**1,233.3**	**1,254.3**	**1,253.3**	**1,286.4**	**1,205.7**
Synthetic Fertilizer	288.3	465.8	464.0	452.0	454.4	471.6	470.4	495.0
Residue N / Biological N fixation	261.8	258.2	256.3	291.1	292.2	292.2	330.7	318.4
Managed Manure	2.233	1.7	1.8	1.9	3.0	3.9	4.2	3.3
Other Organic N Inputs	0.015	0.1	0.3	0.4	0.2	0.6	0.2	0.0
Mineralization & Asymbiotic Fixation	362.3	423.0	372.2	488.0	504.4	485.0	480.8	389.2
Ohio	**1,111**	**1,191.6**	**1,203.2**	**1,074.5**	**1,258.2**	**1,238.6**	**1,190.3**	**1,209.3**
Synthetic Fertilizer	402.7	441.5	383.2	408.8	419.7	397.8	375.0	373.4
Residue N / Biological N fixation	199.1	231.4	223.2	204.0	294.1	256.6	274.1	245.8
Managed Manure	34.93	34.3	34.1	32.0	31.9	34.1	32.3	30.0
Other Organic N Inputs	0.804	0.7	0.2	1.0	0.2	0.1	0.2	0.0
Mineralization & Asymbiotic Fixation	473.1	483.8	562.5	428.7	512.4	550.0	508.6	560.1
Oklahoma	**584.8**	**615.8**	**548.2**	**558.7**	**587.0**	**594.0**	**585.1**	**474.1**
Synthetic Fertilizer	333.5	307.5	287.6	269.7	295.1	267.1	273.9	108.3
Residue N / Biological N fixation	70.47	84.1	74.8	79.5	75.3	69.5	66.1	70.1
Managed Manure	5.237	5.5	6.3	5.8	5.1	6.3	5.7	1.3
Other Organic N Inputs	0	0.0	0.2	0.5	0.3	0.1	0.0	0.0
Mineralization & Asymbiotic Fixation	175.5	218.7	179.3	203.3	211.1	251.0	239.4	294.4
Oregon	**179.3**	**187.9**	**174.7**	**175.0**	**177.6**	**176.0**	**176.2**	**153.3**
Synthetic Fertilizer	70.2	69.9	67.6	69.6	71.8	70.2	71.7	36.2
Residue N / Biological N fixation	54.52	52.2	54.4	50.8	46.7	47.6	47.1	52.0
Managed Manure	2.672	3.1	1.8	1.8	1.3	1.1	1.2	0.7
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	51.91	62.6	50.9	52.6	57.9	57.1	56.2	64.4
Pennsylvania	**508.5**	**519.8**	**602.8**	**501.2**	**572.4**	**610.3**	**640.4**	**651.6**
Synthetic Fertilizer	72.25	85.5	99.2	70.2	90.9	100.5	141.0	142.4
Residue N / Biological N fixation	129	148.9	150.4	145.1	149.1	150.6	150.8	149.3
Managed Manure	59.84	65.4	59.0	60.4	59.7	64.4	61.3	59.0
Other Organic N Inputs	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.0
Mineralization & Asymbiotic Fixation	247.4	219.9	294.2	225.4	272.5	294.6	287.3	300.8
Rhode Island	**1.56**	**1.4**	**1.4**	**1.5**	**1.6**	**1.5**	**1.7**	**1.8**
Synthetic Fertilizer	0.683	0.6	0.6	0.6	0.6	0.6	0.8	0.7
Residue N / Biological N fixation	0.369	0.4	0.3	0.3	0.3	0.4	0.4	0.4
Managed Manure	0.013	0.0	0.0	0.1	0.1	0.0	0.0	0.1
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	0.495	0.4	0.5	0.5	0.6	0.5	0.5	0.6
South Carolina	**190.1**	**201.5**	**219.5**	**212.5**	**217.6**	**219.0**	**201.5**	**193.7**
Synthetic Fertilizer	61.07	62.5	68.5	63.0	54.9	66.6	62.5	55.4

Residue N / Biological N fixation	34.61	34.5	49.8	49.1	53.9	41.0	38.9	30.1
Managed Manure	13.54	14.0	13.0	11.7	12.7	14.8	13.6	11.6
Other Organic N Inputs	0.04	0.0	0.0	0.3	0.1	0.1	0.1	0.0
Mineralization & Asymbiotic Fixation	80.8	90.5	88.3	88.4	96.0	96.4	86.3	96.6
South Dakota	**1,025**	**1,122.9**	**1,161.2**	**1,471.2**	**1,603.3**	**1,652.0**	**1,734.6**	**1,708.7**
Synthetic Fertilizer	174.7	177.1	323.2	459.2	455.2	600.9	620.7	562.9
Residue N / Biological N fixation	308.2	323.4	373.7	341.7	369.7	385.7	404.3	376.8
Managed Manure	39.5	33.8	38.4	40.8	40.5	48.5	44.8	35.9
Other Organic N Inputs	0.08	0.1	0.2	0.4	0.1	0.4	0.0	0.0
Mineralization & Asymbiotic Fixation	502.7	588.6	425.7	629.2	737.7	616.6	664.6	733.0
Tennessee	**416**	**458.3**	**438.6**	**435.0**	**416.0**	**564.6**	**545.9**	**487.8**
Synthetic Fertilizer	158.3	168.0	148.4	160.5	105.4	199.2	200.9	142.4
Residue N / Biological N fixation	87.91	98.0	103.3	101.7	121.0	103.9	105.1	100.7
Managed Manure	6.468	5.7	6.0	6.0	7.3	8.0	7.2	5.6
Other Organic N Inputs	0.295	0.5	0.1	0.5	0.5	0.1	0.1	0.0
Mineralization & Asymbiotic Fixation	163.1	186.0	180.8	166.4	181.8	253.4	232.7	239.2
Texas	**1,642**	**1,855.9**	**1,742.5**	**1,590.0**	**1,738.2**	**1,456.9**	**1,575.2**	**1,671.8**
Synthetic Fertilizer	803.1	890.2	967.5	792.9	765.5	605.8	660.9	637.7
Residue N / Biological N fixation	250.8	268.0	263.2	283.3	242.6	204.9	198.0	196.0
Managed Manure	13.96	15.9	20.3	15.4	20.1	16.0	15.9	11.3
Other Organic N Inputs	0.132	0.1	0.2	0.9	1.9	0.2	0.1	0.0
Mineralization & Asymbiotic Fixation	574.3	681.8	491.2	497.6	708.2	630.1	700.3	826.7
Utah	**91.28**	**89.3**	**86.8**	**92.5**	**81.6**	**96.6**	**96.3**	**87.0**
Synthetic Fertilizer	18.93	16.9	17.5	11.2	13.3	20.0	17.5	10.0
Residue N / Biological N fixation	30.98	36.1	29.0	31.6	26.7	26.6	24.0	25.5
Managed Manure	6.565	0.9	2.9	3.7	5.2	9.0	6.1	2.8
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	34.81	35.4	37.5	46.1	36.4	40.9	48.7	48.7
Vermont	**69.77**	**60.4**	**66.5**	**71.6**	**72.1**	**73.7**	**77.0**	**78.6**
Synthetic Fertilizer	6.254	4.8	5.7	8.3	9.5	10.0	15.9	16.4
Residue N / Biological N fixation	24	24.3	23.1	21.3	21.6	20.6	21.4	21.0
Managed Manure	2.574	2.3	3.0	2.9	2.9	3.6	3.6	3.0
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	36.94	29.0	34.7	39.1	38.2	39.5	36.1	38.3
Virginia	**274.8**	**303.9**	**349.5**	**282.3**	**316.4**	**342.2**	**335.0**	**339.5**
Synthetic Fertilizer	88.71	93.2	103.1	75.6	89.1	81.1	84.1	83.4
Residue N / Biological N fixation	61.04	70.7	79.4	74.2	78.8	84.5	82.7	78.5
Managed Manure	16.14	12.4	16.4	17.6	15.3	20.1	17.3	14.2
Other Organic N Inputs	0.061	0.0	0.1	0.2	0.0	0.2	0.1	0.0
Mineralization & Asymbiotic Fixation	108.9	127.7	150.4	114.7	133.3	156.3	150.8	163.4
Washington	**279.9**	**290.5**	**283.5**	**273.2**	**269.9**	**272.8**	**250.5**	**188.7**
Synthetic Fertilizer	140.4	137.8	149.1	129.6	122.7	128.5	126.4	58.6
Residue N / Biological N fixation	60.68	69.3	72.3	65.2	66.3	70.3	65.0	64.7
Managed Manure	7.863	9.1	8.7	7.6	5.6	11.5	9.3	2.1
Other Organic N Inputs	0.032	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	70.96	74.2	53.3	70.9	75.3	62.5	49.9	63.4

West Virginia	**77.51**	**76.9**	**92.3**	**94.8**	**72.2**	**72.9**	**67.2**	**66.5**
Synthetic Fertilizer	8.476	7.6	7.8	28.7	9.7	7.0	5.1	5.0
Residue N / Biological N fixation	29.72	32.1	35.3	30.8	27.9	26.4	26.0	25.0
Managed Manure	3.14	2.7	1.8	1.9	1.6	2.5	2.0	1.7
Other Organic N Inputs	0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	36.17	34.6	47.3	33.3	33.1	37.0	34.1	34.8
Wisconsin	**1,082**	**992.4**	**1,039.7**	**986.6**	**1,177.2**	**1,074.2**	**1,132.3**	**1,056.1**
Synthetic Fertilizer	237.2	213.6	219.1	243.5	276.9	305.5	296.0	239.5
Residue N / Biological N fixation	253.4	241.9	234.6	236.3	249.7	238.9	244.7	231.0
Managed Manure	63.52	70.4	70.5	55.8	65.8	71.8	75.7	48.9
Other Organic N Inputs	0.865	1.0	0.8	0.1	0.1	0.1	0.0	0.0
Mineralization & Asymbiotic Fixation	527	465.5	514.8	450.9	584.7	457.9	515.8	536.7
Wyoming	**146.6**	**150.3**	**143.7**	**149.4**	**149.5**	**146.9**	**158.3**	**158.7**
Synthetic Fertilizer	32.47	35.9	35.8	33.2	28.8	31.0	33.5	27.3
Residue N / Biological N fixation	53.86	56.7	58.9	56.3	62.9	48.4	52.1	59.3
Managed Manure	3.463	3.4	3.6	4.2	3.8	3.4	4.8	3.5
Other Organic N Inputs	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineralization & Asymbiotic Fixation	56.8	54.3	45.4	55.7	54.0	64.1	67.9	68.7

Note: Gg N is gigagrams of nitrogen. Nitrogen inputs for croplands that were included in the Tier 3 method only. See Appendix Table B-12 for proportion of cropland estimated with the Tier 3 method.

Appendix Table B-2 State-Level Soil Nitrous Oxide Emissions From Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Source				*MMT CO_2 eq.*				
Alabama	**1.1**	**1.2**	**1.2**	**1.2**	**1.1**	**1.3**	**1.3**	**1.3**
Direct Soil N_2O	0.9	0.9	0.9	0.9	0.8	0.9	1.0	1.0
Indirect Soil N_2O	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.4
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arizona	**0.2**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**
Direct Soil N_2O	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**5.2**	**4.9**	**5.2**	**4.6**	**4.8**	**5.2**	**5.3**	**5.3**
Direct Soil N_2O	3.9	4.0	4.2	3.8	3.9	4.0	4.2	4.1
Indirect Soil N_2O	1.2	1.0	1.1	0.8	0.8	1.2	1.1	1.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
California	**1.2**	**1.3**	**1.2**	**1.2**	**1.2**	**1.1**	**1.2**	**1.1**
Direct Soil N_2O	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Indirect Soil N_2O	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colorado	**3.4**	**3.8**	**2.9**	**3.3**	**3.2**	**3.5**	**3.7**	**3.4**
Direct Soil N_2O	3.3	3.6	2.8	3.1	3.0	3.4	3.5	3.1
Indirect Soil N_2O	0.1	0.3	0.1	0.2	0.2	0.2	0.2	0.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Connecticut	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Direct Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**
Direct Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florida	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**
Direct Soil N_2O	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Indirect Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	**1.5**	**1.7**	**1.8**	**1.8**	**1.7**	**1.9**	**1.7**	**1.8**
Direct Soil N_2O	1.2	1.2	1.4	1.3	1.3	1.3	1.2	1.3
Indirect Soil N_2O	0.3	0.5	0.5	0.5	0.4	0.6	0.5	0.5
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	**2.1**	**2.5**	**2.2**	**2.3**	**2.1**	**2.1**	**2.3**	**2.0**
Direct Soil N_2O	2.0	2.1	2.1	2.1	2.0	2.0	2.2	1.8
Indirect Soil N_2O	0.1	0.4	0.1	0.2	0.1	0.1	0.1	0.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illinois	**19.0**	**16.1**	**16.4**	**14.3**	**16.1**	**17.9**	**18.7**	**18.4**
Direct Soil N_2O	15.1	13.0	13.3	11.9	13.0	14.2	15.1	14.4
Indirect Soil N_2O	4.0	3.1	3.1	2.3	3.0	3.7	3.6	4.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indiana	**9.2**	**8.1**	**8.6**	**7.8**	**8.8**	**9.6**	**9.3**	**9.0**
Direct Soil N_2O	7.1	6.5	6.6	6.2	6.9	7.3	7.2	6.7
Indirect Soil N_2O	2.1	1.7	2.0	1.6	1.9	2.3	2.0	2.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iowa	**20.0**	**18.1**	**16.5**	**19.3**	**19.0**	**19.4**	**24.8**	**21.2**
Direct Soil N_2O	16.3	15.2	14.5	16.4	14.9	15.8	20.8	17.3
Indirect Soil N_2O	3.7	2.9	2.1	2.9	4.1	3.6	4.1	3.9
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kansas	**13.1**	**14.2**	**12.3**	**15.9**	**15.4**	**18.1**	**16.1**	**16.3**
Direct Soil N_2O	11.9	12.7	11.3	14.4	13.8	16.5	14.8	14.3
Indirect Soil N_2O	1.2	1.5	1.0	1.5	1.6	1.6	1.3	2.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kentucky	**2.8**	**2.8**	**3.0**	**2.7**	**2.9**	**3.5**	**3.5**	**3.7**
Direct Soil N_2O	2.1	2.2	2.4	2.2	2.4	2.7	2.9	2.8
Indirect Soil N_2O	0.6	0.6	0.6	0.5	0.5	0.9	0.7	0.9
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Louisiana	**3.3**	**3.1**	**3.2**	**2.9**	**2.9**	**3.2**	**3.1**	**3.3**
Direct Soil N_2O	2.7	2.5	2.6	2.4	2.4	2.6	2.5	2.6
Indirect Soil N_2O	0.6	0.6	0.6	0.5	0.4	0.6	0.6	0.7
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Maine	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Direct Soil N_2O	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	**0.8**	**0.8**	**0.8**	**0.7**	**0.6**	**0.8**	**0.8**	**0.7**
Direct Soil N_2O	0.6	0.6	0.6	0.5	0.5	0.6	0.6	0.5
Indirect Soil N_2O	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Massachusetts	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Direct Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**4.0**	**3.6**	**4.0**	**3.3**	**3.8**	**3.9**	**3.9**	**3.7**
Direct Soil N_2O	3.0	2.8	3.0	2.7	2.9	2.9	2.9	2.8
Indirect Soil N_2O	1.1	0.8	1.1	0.7	0.9	1.0	1.0	0.9
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Minnesota	**13.5**	**13.0**	**11.5**	**13.4**	**12.2**	**11.8**	**14.0**	**13.3**
Direct Soil N_2O	11.6	10.7	10.0	11.1	9.5	9.7	11.4	11.2
Indirect Soil N_2O	2.0	2.3	1.5	2.3	2.7	2.1	2.6	2.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mississippi	**3.4**	**3.2**	**3.4**	**3.0**	**3.1**	**3.4**	**3.6**	**3.5**
Direct Soil N_2O	2.7	2.6	2.7	2.5	2.6	2.8	2.9	2.8
Indirect Soil N_2O	0.7	0.6	0.6	0.5	0.4	0.7	0.7	0.7
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Missouri	**9.7**	**8.4**	**8.3**	**8.1**	**9.4**	**10.5**	**10.3**	**10.7**
Direct Soil N_2O	7.8	6.8	7.0	6.7	7.7	8.5	8.3	8.4
Indirect Soil N_2O	1.8	1.6	1.3	1.4	1.7	2.0	2.0	2.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montana	**6.2**	**6.9**	**5.4**	**5.9**	**6.4**	**6.4**	**7.3**	**6.4**
Direct Soil N_2O	6.1	6.7	5.2	5.7	6.2	6.2	7.1	6.3
Indirect Soil N_2O	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska	**9.8**	**11.3**	**9.7**	**13.0**	**12.5**	**13.2**	**13.4**	**13.2**
Direct Soil N_2O	8.8	9.7	8.9	11.2	10.4	11.7	11.6	11.1
Indirect Soil N_2O	0.9	1.6	0.8	1.7	2.1	1.5	1.9	2.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nevada	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**
Direct Soil N_2O	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Direct Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Direct Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Mexico	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**	**0.6**	**0.6**	**0.6**
Direct Soil N_2O	0.6	0.6	0.5	0.5	0.5	0.6	0.5	0.5
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	**2.2**	**2.1**	**2.4**	**2.2**	**2.3**	**2.5**	**2.2**	**2.3**
Direct Soil N_2O	1.7	1.7	1.9	1.7	1.8	2.0	1.8	1.8
Indirect Soil N_2O	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.4
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	**2.1**	**2.2**	**2.1**	**2.0**	**1.9**	**2.2**	**2.1**	**2.1**
Direct Soil N_2O	1.5	1.6	1.6	1.4	1.5	1.5	1.5	1.5
Indirect Soil N_2O	0.5	0.6	0.5	0.5	0.5	0.6	0.6	0.6
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Dakota	**7.3**	**8.2**	**7.9**	**7.6**	**8.1**	**8.4**	**8.5**	**7.8**
Direct Soil N_2O	7.1	7.9	7.6	7.3	7.8	8.1	8.2	7.5
Indirect Soil N_2O	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ohio	**8.0**	**7.4**	**7.2**	**6.7**	**7.2**	**7.6**	**7.0**	**7.3**
Direct Soil N_2O	6.2	5.9	5.7	5.3	5.8	5.9	5.7	5.5
Indirect Soil N_2O	1.8	1.5	1.5	1.4	1.4	1.7	1.3	1.7
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Oklahoma	**4.4**	**4.1**	**3.7**	**3.8**	**4.4**	**5.0**	**4.5**	**4.6**
Direct Soil N_2O	3.9	3.5	3.2	3.4	3.9	4.4	4.1	3.8
Indirect Soil N_2O	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.8
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oregon	**1.3**	**1.3**	**1.2**	**1.4**	**1.5**	**1.4**	**1.3**	**1.0**
Direct Soil N_2O	1.2	1.1	1.1	1.3	1.4	1.3	1.2	0.9
Indirect Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pennsylvania	**2.4**	**2.2**	**2.4**	**2.4**	**2.3**	**2.6**	**2.7**	**2.7**
Direct Soil N_2O	1.8	1.8	1.9	1.9	1.8	2.0	2.1	2.1
Indirect Soil N_2O	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.6
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhode Island	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Direct Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect Soil N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	**1.0**	**1.1**	**1.1**	**1.1**	**1.0**	**1.1**	**1.0**	**1.1**
Direct Soil N_2O	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.8
Indirect Soil N_2O	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Dakota	**8.0**	**8.7**	**7.1**	**9.6**	**9.9**	**10.9**	**12.2**	**10.8**
Direct Soil N_2O	7.6	7.8	6.8	8.8	8.8	10.0	11.3	10.1
Indirect Soil N_2O	0.3	0.8	0.3	0.9	1.0	0.8	0.9	0.8
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tennessee	**2.3**	**2.3**	**2.2**	**2.1**	**2.2**	**2.9**	**2.9**	**2.6**
Direct Soil N_2O	1.7	1.8	1.8	1.7	1.7	2.1	2.2	2.0
Indirect Soil N_2O	0.6	0.5	0.4	0.4	0.4	0.7	0.6	0.6
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Texas	**13.0**	**13.0**	**12.9**	**11.1**	**13.1**	**12.2**	**13.1**	**13.7**
Direct Soil N_2O	11.9	11.9	11.6	10.1	11.6	11.2	11.7	11.4
Indirect Soil N_2O	1.1	1.1	1.3	0.9	1.4	1.0	1.3	2.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utah	**0.5**	**0.6**	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Direct Soil N_2O	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
Indirect Soil N_2O	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vermont	**0.3**	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.3**	**0.4**
Direct Soil N_2O	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Indirect Soil N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	**1.2**	**1.3**	**1.4**	**1.2**	**1.2**	**1.4**	**1.3**	**1.4**
Direct Soil N_2O	0.9	1.0	1.1	0.9	1.0	1.0	1.0	1.1
Indirect Soil N_2O	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Washington	**2.7**	**2.3**	**2.3**	**2.5**	**2.7**	**2.0**	**3.1**	**1.7**
Direct Soil N_2O	2.6	2.2	2.2	2.5	2.6	2.0	3.1	1.7
Indirect Soil N_2O	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.3**	**0.3**	**0.2**
Direct Soil N_2O	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Indirect Soil N_2O	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wisconsin	**5.6**	**5.4**	**5.1**	**5.0**	**5.7**	**5.5**	**6.2**	**6.0**
Direct Soil N_2O	4.5	4.4	4.1	4.3	4.4	4.3	4.9	4.7
Indirect Soil N_2O	1.2	1.1	1.0	0.7	1.3	1.2	1.3	1.2
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wyoming	**0.8**	**0.7**	**0.6**	**0.7**	**0.6**	**0.7**	**0.9**	**0.8**
Direct Soil N_2O	0.8	0.7	0.6	0.6	0.6	0.7	0.8	0.7
Indirect Soil N_2O	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Residue Burning N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent. Soil Direct and Indirect Nitrous Oxide estimates based on analysis for the Tier 3 method only. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method.

Appendix Table B-3 State-Level Cropland Areas With Residue Burning Management and Rice Cultivation (Rice Harvested Areas in Parentheses), 1990, 1995, 2000, 2005, 2010, 2013–2015

		1990	1995	2000	2005	2010	2013	2014	2015
State	Source	*1,000 hectares*							
Alabama	Residue Burning	19.6	18.1	17.3	14.6	13.6	15.9	14.9	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Arizona	Residue Burning	7.1	6.4	7.4	8.1	6.8	6.9	7.9	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Arkansas	Residue Burning	0.0	0.0	0.0	101.9	142.1	44.4	47.5	ND
	Rice Cultivation	594.2 (600.2)	599.9 (605.9)	620.5 (626.7)	776.2 (784)	805.8 (813.9)	562.4 (568)	693.4 (700.3)	672.4 (679.2)
California	Residue Burning	62.7	30.1	12.5	1.4	12.1	24.2	29.5	ND
	Rice Cultivation	248.6 (248.6)	267.3 (267.3)	272 (272)	235.7 (235.7)	254 (254)	255 (255)	257 (257)	280 (280)
Colorado	Residue Burning	28.0	26.6	24.7	26.2	23.7	23.6	27.7	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Connecticut	Residue Burning	0.4	0.3	0.3	0.4	0.3	0.4	0.3	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Delaware	Residue Burning	1.5	1.6	2.0	1.9	1.7	2.4	2.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Florida	Residue Burning	0.0	0.0	0.0	22.7	30.1	26.2	27.1	ND
	Rice Cultivation	0 (0)	0 (0)	107.5 (160.2)	2.8 (4.2)	0 (0)	0 (0)	0 (0)	0 (0)
Georgia	Residue Burning	32.5	32.6	33.6	34.8	32.6	32.7	35.3	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Idaho	Residue Burning	8.6	8.7	10.0	9.5	8.9	9.9	9.7	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Illinois	Residue Burning	81.5	80.2	87.9	81.3	77.9	80.6	80.4	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0.5 (0.5)	0.5 (0.5)	0 (0)	0 (0)	0 (0)
Indiana	Residue Burning	0.0	0.0	0.0	0.0	7.1	25.7	0.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Iowa	Residue Burning	0.0	0.0	0.0	8.3	29.1	0.0	13.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Kansas	Residue Burning	98.2	92.8	106.7	103.5	92.3	101.3	100.2	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Kentucky	Residue Burning	12.5	13.1	15.9	14.5	15.2	19.3	18.2	ND
	Rice Cultivation	0 (0)	0 (0)	0.3 (0.3)	0.3 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)
Louisiana	Residue Burning	63.2	55.9	68.0	63.4	57.7	57.4	60.4	ND
	Rice Cultivation	288.5 (380.8)	261.3 (345)	314.7 (415.4)	304.8 (402.3)	254.9 (336.5)	231.2 (305.1)	284.2 (375.2)	278.6 (367.7)
Maine	Residue Burning	0.4	0.3	0.3	0.3	0.3	0.3	0.3	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Maryland	Residue Burning	7.1	7.5	8.1	6.9	6.5	7.5	7.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Massachusetts	Residue Burning	0.4	0.3	0.3	0.3	0.3	0.3	0.3	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Michigan	Residue Burning	10.9	9.9	12.0	12.4	12.4	12.7	12.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Minnesota	Residue Burning	22.7	21.6	25.4	23.3	23.6	22.2	22.2	ND
	Rice Cultivation	3.7 (3.7)	4.7 (4.7)	10.2 (10.2)	9.3 (9.3)	9.8 (9.8)	4.3 (4.3)	1.1 (1.1)	1.1 (1.1)
Mississippi	Residue Burning	37.7	34.8	33.4	34.0	30.2	31.4	31.6	ND
	Rice Cultivation	121.8 (123)	135.9 (137.2)	124.1 (125.3)	136.9 (138.2)	104.9 (106)	90.6 (91.5)	91.2 (92.1)	97.5 (98.5)
Missouri	Residue Burning	46.0	44.0	52.1	47.1	46.4	50.5	51.1	ND
	Rice Cultivation	47.5 (48)	52.3 (52.8)	86 (86.9)	92.9 (93.8)	110.7 (111.8)	76.8 (77.6)	92.5 (93.4)	61.4 (62)
Montana	Residue Burning	25.2	25.2	25.8	25.2	24.5	26.5	28.7	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nebraska	Residue Burning	33.4	32.4	36.7	38.7	38.3	38.1	39.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nevada	Residue Burning	0.8	0.7	0.6	1.1	0.6	0.7	0.5	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
New Hampshire	Residue Burning	0.1	0.1	0.1	0.1	0.1	0.1	0.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
New Jersey	Residue Burning	2.2	2.0	2.1	1.7	1.7	1.7	1.7	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

New Mexico	Residue Burning	11.1	11.0	11.3	9.6	8.6	9.5	8.4	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
New York	Residue Burning	5.4	5.3	5.5	4.9	5.3	5.1	5.2	ND
	Rice Cultivation	0.6 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
North Carolina	Residue Burning	25.7	28.9	28.1	23.6	31.3	32.5	33.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
North Dakota	Residue Burning	41.0	40.9	50.4	48.6	45.4	39.0	45.4	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ohio	Residue Burning	35.8	36.5	38.3	37.5	36.0	34.8	34.6	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Oklahoma	Residue Burning	85.1	79.4	73.0	71.4	65.9	69.3	66.5	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Oregon	Residue Burning	10.0	9.1	9.8	9.2	8.7	8.5	8.7	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pennsylvania	Residue Burning	13.1	12.5	13.0	12.8	12.6	12.6	12.3	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhode Island	Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
South Carolina	Residue Burning	18.1	15.1	14.2	12.9	12.5	18.1	18.2	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
South Dakota	Residue Burning	30.1	24.4	34.2	34.3	33.1	31.0	32.2	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Tennessee	Residue Burning	18.6	16.8	19.7	18.7	20.3	24.6	23.2	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	1.1 (1.1)	0 (0)	0 (0)	0.2 (0.2)	0 (0)
Texas	Residue Burning	171.4	164.8	163.7	148.9	143.4	139.6	136.2	ND
	Rice Cultivation	208.5 (302.3)	224.1 (324.9)	136.7 (198.2)	81.6 (118.3)	94.2 (136.6)	83.6 (121.2)	77 (111.6)	90.2 (130.7)
Utah	Residue Burning	2.7	2.3	2.4	2.1	2.1	3.1	2.6	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vermont	Residue Burning	0.6	0.5	0.5	0.5	0.5	0.5	0.5	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Virginia	Residue Burning	14.6	15.3	17.1	17.6	14.8	14.9	16.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Washington	Residue Burning	60.1	0.0	0.0	39.3	8.8	3.2	9.0	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
West Virginia	Residue Burning	1.8	1.6	1.6	1.3	1.3	1.1	1.1	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wisconsin	Residue Burning	16.8	15.8	16.9	16.6	17.1	17.9	17.6	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wyoming	Residue Burning	2.3	2.7	2.1	2.4	2.0	2.4	2.4	ND
	Rice Cultivation	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Note: The designation 'ND' means that the areas are not determined. This information will be updated in the future when data are available.

Appendix Table B-4 State-Level Methane Emissions From Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015

	1990	1995	2000	2005	2010	2013	2014	2015
Source	*MMT CO_2 eq.*							
Alabama	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arizona	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**5.4**	**5.4**	**6.3**	**7.9**	**8.9**	**4.8**	**5.7**	**6.4**
Residue Burning	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Rice Cultivation	5.4	5.4	6.3	7.9	8.9	4.7	5.7	6.4
California	**3.3**	**3.4**	**3.7**	**3.4**	**3.4**	**3.7**	**3.9**	**4.2**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	3.3	3.4	3.7	3.4	3.4	3.7	3.9	4.1
Colorado	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Connecticut	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florida	**0.0**	**0.0**	**1.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0
Georgia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illinois	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indiana	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iowa	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kansas	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kentucky	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Louisiana	**2.6**	**2.4**	**3.1**	**2.8**	**2.7**	**2.3**	**3.3**	**2.6**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	2.6	2.4	3.0	2.8	2.7	2.2	3.2	2.6
Maine	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Massachusetts	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Minnesota	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Mississippi	**1.1**	**1.3**	**1.3**	**1.4**	**1.1**	**0.8**	**0.8**	**1.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	1.1	1.3	1.3	1.4	1.1	0.8	0.8	1.0
Missouri	**0.6**	**0.6**	**1.1**	**1.1**	**1.4**	**0.8**	**0.9**	**0.7**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.6	0.5	1.1	1.1	1.4	0.8	0.8	0.7
Montana	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nevada	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Mexico	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Dakota	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ohio	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oklahoma	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oregon	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pennsylvania	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhode Island	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Dakota	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tennessee	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Texas	**3.1**	**3.5**	**2.0**	**1.4**	**1.4**	**1.5**	**1.0**	**1.5**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	3.0	3.4	2.0	1.3	1.3	1.5	0.9	1.4
Utah	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vermont	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Washington	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wisconsin	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wyoming	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Residue Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice Cultivation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

Appendix Table B-5 State-Level Cropland Area With Mineral and Organic Soils, and Total Amount of Carbonate Lime[1] and Urea Fertilizer Applied to Cropland Soils, 1990, 1995, 2000, 2005, 2010, 2013–2015.

		1990	1995	2000	2005	2010	2013	2014	2015
State	Source	*Million hectares (Mineral and Organic Soils) and 1,000 Metrics tonnes (Lime and Urea)*							
Alabama	Mineral Soils	1.6	1.5	1.3	1.2	1.1	1.1	1.1	1.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	357.9	379.4	320.6	0.0	593.1	229.4	0.0	0.0
	Urea	7.8	11.4	13.6	13.6	8.3	9.4	9.2	9.2
Alaska	Mineral Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	5.5	5.3	4.7	4.9	4.9	5.3	5.2	5.1
Arizona	Mineral Soils	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	18.1	24.3	13.5	14.6	14.0	6.0	7.2	8.3
Arkansas	Mineral Soils	3.3	3.3	3.2	3.1	3.1	3.1	3.0	3.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	194.5	290.4	302.6	342.1	299.0	102.9	129.1	152.8
	Urea	313.5	357.4	395.9	328.7	347.2	302.4	325.5	328.4
California	Mineral Soils	4.4	4.3	4.2	4.0	3.9	4.0	4.0	4.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	36.2	101.9	188.0	249.8	528.5	711.7	463.1	11.8
	Urea	58.1	92.8	120.6	126.5	124.5	129.1	122.4	125.4
Colorado	Mineral Soils	4.5	4.4	4.3	4.2	4.1	4.1	4.1	4.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	32.4	27.8	23.8	44.7	43.5	63.1	53.3	56.5
Connecticut	Mineral Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0
	Urea	1.3	2.7	4.3	0.9	1.5	1.6	1.4	1.3
Delaware	Mineral Soils	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	0.4	0.3	0.3	0.5	1.4	3.3	3.1	3.8
District of Columbia	Mineral Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	6.6	11.0	17.7	7.4	7.6	8.8	7.6	5.6
Florida	Mineral Soils	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0
	Organic Soils	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Carbonate Lime	1,492.7	935.5	820.9	880.1	1,019.8	920.8	841.6	679.0
	Urea	8.0	16.9	10.7	14.2	51.5	44.9	46.7	54.4
Georgia	Mineral Soils	2.5	2.3	2.0	1.9	1.9	1.9	2.0	1.9
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	109.9	0.0	0.0	0.0
	Urea	2.4	2.2	1.8	1.8	1.8	2.0	1.9	1.9
Hawaii	Mineral Soils	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	75.2	103.3	116.0	175.4	115.9	150.0	88.6	79.4
Idaho	Mineral Soils	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.5
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	61.5	0.0	0.0	0.0	0.0	0.0
	Urea	161.3	106.5	78.1	76.9	62.5	88.9	86.5	86.7
Illinois	Mineral Soils	10.3	10.3	10.2	10.1	10.0	10.0	10.0	10.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	3,006.5	3,149.6	1,964.8	3,435.2	3,086.9	2,833.3	2,627.2	2,690.3
	Urea	104.1	70.4	61.4	88.1	84.3	108.4	109.6	99.6
Indiana	Mineral Soils	5.8	5.7	5.6	5.5	5.5	5.5	5.5	5.5
	Organic Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Carbonate Lime	1,764.5	1,779.7	1,603.2	2,356.4	3,006.1	2,361.1	2,048.3	2,408.7
	Urea	170.7	185.4	197.6	210.2	130.3	186.4	198.0	208.8
Iowa	Mineral Soils	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.0

	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	1,456.5	1,545.5	1,201.8	0.0	1,454.6	538.0	475.0	1,463.2
	Urea	142.8	109.1	218.1	275.0	257.0	295.1	311.1	351.7
Kansas	Mineral Soils	12.2	12.1	12.0	11.9	11.7	11.6	11.7	11.6
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	173.3	206.1	121.7	266.9	101.8	109.6	87.6	131.6
	Urea	117.6	95.7	102.0	78.7	83.0	95.4	98.2	102.2
Kentucky	Mineral Soils	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.4
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	1,952.8	1,241.1	871.5	0.0	690.1	669.5	526.9	613.4
	Urea	71.6	58.6	86.7	93.7	174.0	156.5	172.9	235.0
Louisiana	Mineral Soils	2.6	2.4	2.4	2.2	2.2	2.1	2.1	2.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	2.8	3.5	4.8	9.7	5.7	2.3	0.8	0.7
Maine	Mineral Soils	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	6.2	7.9	13.0	9.1	5.8	10.8	9.4	8.6
Maryland	Mineral Soils	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	3.6	3.8	4.4	4.1	2.4	1.2	1.0	1.0
Massachusetts	Mineral Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	98.6	0.0	0.0	0.0
	Urea	99.7	83.3	109.4	98.0	74.2	106.9	95.1	92.3
Michigan	Mineral Soils	3.8	3.7	3.6	3.4	3.4	3.4	3.4	3.4
	Organic Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Carbonate Lime	258.1	154.6	85.6	146.2	373.3	1,293.5	1,439.8	0.0
	Urea	293.4	446.3	424.7	482.2	566.4	637.3	660.7	690.1
Minnesota	Mineral Soils	9.5	9.5	9.3	9.2	9.1	9.1	9.1	9.0
	Organic Soils	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Carbonate Lime	299.3	186.2	377.3	53.9	193.9	285.0	78.7	157.5
	Urea	78.8	59.5	66.4	68.2	51.3	68.6	67.4	68.1
Mississippi	Mineral Soils	2.8	2.6	2.4	2.3	2.3	2.2	2.2	2.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	129.7	0.0	0.0	0.0	156.8	0.0	0.0	0.0
	Urea	239.4	165.1	167.1	185.3	216.7	224.3	246.2	271.1
Missouri	Mineral Soils	6.2	6.4	6.3	6.2	6.3	6.4	6.5	6.5
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	1,769.5	1,428.5	1,197.0	1,216.5	1,359.2	1,595.4	1,430.9	743.6
	Urea	64.5	122.0	181.5	139.7	279.2	315.2	333.0	322.0
Montana	Mineral Soils	7.3	7.3	7.2	7.2	7.1	7.0	7.0	6.9
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0
	Urea	56.8	73.6	98.6	121.7	138.7	174.5	194.5	217.0
Nebraska	Mineral Soils	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	286.8	345.4	401.4	0.0	408.9	0.0	338.4	0.0
	Urea	0.2	0.6	0.9	1.1	1.9	1.4	1.9	1.6
Nevada	Mineral Soils	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	0.6	1.5	1.0	0.7	2.7	0.2	0.2	0.2
New Hampshire	Mineral Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	6.2	2.2	4.8	4.3	2.8	4.2	3.7	3.8
New Jersey	Mineral Soils	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	13.4	9.9	8.5	16.5	8.1	5.9	9.4	11.0
New Mexico	Mineral Soils	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	26.4	28.9	39.9	31.4	30.7	47.2	50.0	57.1
New York	Mineral Soils	2.4	2.3	2.2	2.1	2.1	2.1	2.1	2.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	Carbonate Lime	0.0	0.0	0.0	0.0	263.4	204.1	77.2	83.6
	Urea	10.1	19.0	11.5	15.3	10.8	10.0	11.5	11.9
North Carolina	Mineral Soils	2.6	2.5	2.4	2.3	2.2	2.2	2.2	2.2
	Organic Soils	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	117.2	0.0	0.0	0.0	3.2	0.0	0.0	0.0
	Urea	115.2	279.0	322.1	466.7	590.5	752.0	690.8	684.6
North Dakota	Mineral Soils	11.5	11.5	11.4	11.3	11.1	10.9	10.9	10.8
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	110.3	136.3	172.8	84.7	70.0	73.5	130.3	229.4
Ohio	Mineral Soils	5.1	5.0	4.8	4.8	4.7	4.7	4.7	4.7
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	932.8	1,083.1	782.3	887.2	1,558.0	578.5	400.8	607.7
	Urea	152.5	125.1	158.2	181.5	174.4	174.4	184.9	196.6
Oklahoma	Mineral Soils	4.7	4.6	4.2	4.1	4.0	3.9	3.9	3.9
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	323.0	288.0	194.1	174.6	213.3	276.6	498.7	382.0
	Urea	85.6	98.0	71.6	159.4	164.5	187.4	193.4	189.6
Oregon	Mineral Soils	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.8
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	34.2	39.2	56.1	31.9	34.9	46.6	61.2	65.0
Pennsylvania	Mineral Soils	2.4	2.4	2.2	2.2	2.1	2.1	2.1	2.1
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	915.3	788.0	678.7	0.0	1,570.9	565.0	731.8	336.5
	Urea	0.1	0.1	0.8	0.1	0.1	0.1	0.1	0.2
Rhode Island	Mineral Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	5.5	5.5	15.1	8.8	6.1	6.6	6.4	7.5
South Carolina	Mineral Soils	1.4	1.2	1.1	1.0	1.0	0.9	0.9	0.9
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	147.8	124.0	389.7	578.9	583.8	714.1	690.4	658.0
South Dakota	Mineral Soils	7.7	7.8	7.7	7.7	7.7	7.7	7.7	7.7
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	101.0	69.7	64.9	57.8	48.6	139.3	140.1	123.4
Tennessee	Mineral Soils	2.2	2.2	2.1	2.0	2.0	2.1	2.0	2.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	679.6	688.5	1916.6	356.3	345.9	286.7	285.0	233.5
	Urea	151.1	228.8	297.0	142.1	141.4	138.7	160.8	181.9
Texas	Mineral Soils	13.5	13.1	12.4	11.8	11.2	11.1	11.1	11.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	633.5	690.8	229.0	0.0	758.0	708.3	690.2	1350.7
	Urea	7.0	3.8	9.4	5.9	10.7	18.4	20.8	25.6
Utah	Mineral Soils	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	63.9	80.9	0.0	0.0	0.0	0.0
	Urea	3.7	2.8	5.7	4.7	7.3	9.7	14.8	15.7
Vermont	Mineral Soils	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	14.3	21.5	31.6	20.9	24.6	29.3	33.6	37.5
Virginia	Mineral Soils	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	1,224.6	988.2	1,398.3	0.0	893.8	855.0	1,092.4	904.7
	Urea	46.0	61.2	52.6	79.9	77.1	72.6	72.1	79.7
Washington	Mineral Soils	3.2	3.2	3.1	3.1	3.1	3.0	3.0	3.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	24.9	2.3	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	3.7	2.5	4.4	47.0	3.4	3.6	2.7	2.7
West Virginia	Mineral Soils	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	22.4	0.0	0.0	0.0	0.0	16.9	0.0	0.0
	Urea	109.5	105.7	116.6	157.3	178.2	275.4	272.3	282.3
Wisconsin	Mineral Soils	4.8	4.7	4.5	4.4	4.4	4.4	4.4	4.4
	Organic Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	Carbonate Lime	593.6	495.3	344.8	0.0	693.3	730.2	531.4	578.1
	Urea	6.9	9.7	10.1	8.3	125.7	151.1	148.5	147.5
Wyoming	Mineral Soils	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Carbonate Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Urea	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0

[1] A portion of the carbonate lime data is considered proprietary information. These data are included in the national emission totals, but are not assigned to specific States. Therefore, some States have more carbonate lime applied to soils than reported in this table.

Appendix Table B-6 State-Level Soil Carbon Change for Mineral Soils and Organic Soils, in Addition to Carbonate Lime[1] and Urea Applications to Cropland Agriculture by State, 1990, 1995, 2000, 2005, 2010, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Source				*MMT CO_2 eq.*				
Alabama	**(0.3)**	**(0.4)**	**(0.6)**	**(0.7)**	**(0.6)**	**(0.3)**	**(0.5)**	**(0.4)**
Mineral Soils	(0.4)	(0.5)	(0.7)	(0.7)	(0.7)	(0.4)	(0.5)	(0.4)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alaska	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mineral Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arizona	**(0.0)**	**0.0**	**0.0**	**0.1**	**0.3**	**0.1**	**0.1**	**0.2**
Mineral Soils	(0.0)	0.0	0.0	0.1	0.2	0.1	0.1	0.2
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**(0.5)**	**(0.4)**	**(0.2)**	**(1.8)**	**(1.2)**	**(0.3)**	**(0.5)**	**(0.4)**
Mineral Soils	(0.7)	(0.7)	(0.6)	(2.1)	(1.5)	(0.5)	(0.8)	(0.6)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Urea	0.2	0.2	0.3	0.2	0.3	0.1	0.2	0.2
California	**2.4**	**2.5**	**1.8**	**1.2**	**1.4**	**1.5**	**1.0**	**0.5**
Mineral Soils	(0.0)	0.1	(0.6)	(1.1)	(1.0)	(1.0)	(1.3)	(1.7)
Organic Soils	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2
Liming of Soils	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.0
Urea	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Colorado	**(0.7)**	**(0.1)**	**(0.3)**	**(0.3)**	**(0.5)**	**(0.2)**	**(0.0)**	**0.1**
Mineral Soils	(0.7)	(0.1)	(0.3)	(0.3)	(0.5)	(0.2)	(0.1)	0.1
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Connecticut	**(0.1)**	**(0.1)**	**(0.0)**	**(0.1)**	**(0.1)**	**(0.0)**	**(0.0)**	**(0.1)**
Mineral Soils	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	**0.0**	**(0.0)**	**(0.0)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.0)**
Mineral Soils	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
District of Columbia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mineral Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florida	**13.5**	**13.5**	**8.1**	**13.6**	**12.7**	**11.6**	**12.5**	**12.1**
Mineral Soils	0.6	0.3	0.2	0.3	0.1	0.3	0.2	0.3
Organic Soils	12.5	12.9	7.6	13.1	12.3	11.1	12.1	11.6
Liming of Soils	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	**(0.4)**	**0.5**	**0.2**	**0.4**	**(0.0)**	**0.0**	**0.1**	**0.4**
Mineral Soils	(0.4)	0.5	0.2	0.4	(0.0)	0.0	0.1	0.4

Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hawaii	**0.3**	**(0.0)**	**0.1**	**0.3**	**0.3**	**0.4**	**0.4**	**0.4**
Mineral Soils	(0.0)	(0.3)	(0.1)	(0.1)	(0.0)	0.0	0.0	0.0
Organic Soils	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Idaho	**(0.5)**	**(0.3)**	**(0.4)**	**(0.2)**	**(0.4)**	**(0.4)**	**(0.4)**	**(0.2)**
Mineral Soils	(0.6)	(0.4)	(0.4)	(0.3)	(0.4)	(0.5)	(0.4)	(0.3)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0
Illinois	**(3.6)**	**(1.1)**	**(4.4)**	**(7.8)**	**(4.1)**	**(1.8)**	**(4.7)**	**(5.5)**
Mineral Soils	(5.1)	(2.6)	(5.7)	(9.3)	(5.4)	(3.1)	(6.0)	(6.8)
Organic Soils	0.7	0.7	0.7	0.7	0.5	0.6	0.6	0.6
Liming of Soils	0.7	0.8	0.5	0.8	0.7	0.7	0.6	0.6
Urea	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Indiana	**0.8**	**2.8**	**2.5**	**(0.1)**	**1.1**	**3.0**	**1.0**	**1.2**
Mineral Soils	(2.3)	(0.7)	(0.7)	(3.3)	(2.3)	(0.3)	(2.2)	(2.2)
Organic Soils	2.6	2.9	2.6	2.6	2.6	2.6	2.6	2.8
Liming of Soils	0.4	0.5	0.4	0.6	0.7	0.6	0.5	0.6
Urea	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Iowa	**(5.3)**	**(3.3)**	**(2.6)**	**(5.5)**	**(3.7)**	**(5.4)**	**(3.1)**	**(3.2)**
Mineral Soils	(6.3)	(4.4)	(3.7)	(6.3)	(4.9)	(6.4)	(4.1)	(4.5)
Organic Soils	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Liming of Soils	0.4	0.4	0.3	0.0	0.3	0.1	0.1	0.3
Urea	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Kansas	**(3.5)**	**(2.3)**	**(3.5)**	**(3.0)**	**(2.8)**	**(0.7)**	**(0.6)**	**(0.7)**
Mineral Soils	(3.6)	(2.4)	(3.6)	(3.2)	(2.9)	(0.8)	(0.7)	(0.8)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1
Kentucky	**(1.0)**	**(0.5)**	**(0.8)**	**(1.1)**	**(1.3)**	**(0.0)**	**(0.6)**	**(0.0)**
Mineral Soils	(1.6)	(0.8)	(1.1)	(1.2)	(1.6)	(0.3)	(0.9)	(0.3)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.5	0.3	0.2	0.0	0.2	0.2	0.1	0.1
Urea	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Louisiana	**(0.3)**	**(0.3)**	**(0.7)**	**(1.0)**	**(1.0)**	**(0.5)**	**(0.8)**	**(0.8)**
Mineral Soils	(0.7)	(0.8)	(1.0)	(1.3)	(1.3)	(0.8)	(1.0)	(1.2)
Organic Soils	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maine	**(0.3)**	**(0.3)**	**(0.1)**	**(0.2)**	**(0.2)**	**(0.2)**	**(0.1)**	**(0.1)**
Mineral Soils	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.1)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	**(0.0)**	**(0.2)**	**0.0**	**(0.2)**	**(0.2)**	**(0.1)**	**(0.2)**	**(0.0)**
Mineral Soils	(0.1)	(0.2)	0.0	(0.2)	(0.2)	(0.1)	(0.2)	(0.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Massachusetts	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**
Mineral Soils	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Organic Soils	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
Michigan	**2.5**	**3.2**	**3.8**	**2.5**	**2.9**	**3.1**	**3.1**	**3.0**
Mineral Soils	(0.9)	(0.4)	0.1	(0.9)	(0.5)	(0.5)	(0.6)	(0.4)
Organic Soils	3.1	3.2	3.3	3.1	2.9	2.9	2.9	2.9
Liming of Soils	0.1	0.0	0.0	0.0	0.1	0.3	0.3	0.0
Urea	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Minnesota	**5.5**	**7.2**	**6.8**	**6.7**	**5.6**	**2.1**	**5.1**	**5.8**
Mineral Soils	(2.2)	(0.5)	(0.7)	(0.6)	(1.7)	(5.4)	(2.6)	(1.8)
Organic Soils	7.6	7.6	7.4	7.3	7.2	7.4	7.6	7.6
Liming of Soils	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Urea	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Mississippi	**(1.1)**	**(1.0)**	**(0.8)**	**(1.6)**	**(1.2)**	**(0.7)**	**(0.7)**	**(0.9)**
Mineral Soils	(1.3)	(1.1)	(1.0)	(1.7)	(1.3)	(0.8)	(0.9)	(1.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Missouri	**(3.6)**	**(2.9)**	**(2.8)**	**(2.8)**	**(2.8)**	**(1.6)**	**(1.4)**	**(2.5)**
Mineral Soils	(4.1)	(3.4)	(3.2)	(3.2)	(3.3)	(2.2)	(1.9)	(2.9)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.4	0.4	0.3	0.3	0.3	0.4	0.3	0.2
Urea	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Montana	**0.2**	**(0.6)**	**(2.2)**	**(1.7)**	**(0.6)**	**(1.6)**	**(0.9)**	**(1.4)**
Mineral Soils	0.1	(0.8)	(2.4)	(1.9)	(0.8)	(1.8)	(1.1)	(1.6)
Organic Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Nebraska	**(3.6)**	**(2.9)**	**(3.6)**	**(2.5)**	**(3.3)**	**(4.7)**	**(3.0)**	**(2.9)**
Mineral Soils	(3.6)	(3.0)	(3.7)	(2.6)	(3.4)	(4.7)	(3.2)	(2.9)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nevada	**(0.1)**	**(0.0)**	**(0.1)**	**(0.1)**	**(0.0)**	**(0.1)**	**(0.0)**	**(0.0)**
Mineral Soils	(0.1)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)	(0.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**(0.0)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.1)**	**(0.0)**	**(0.1)**	**(0.0)**
Mineral Soils	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**
Mineral Soils	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
Organic Soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Mexico	**0.0**	**0.0**	**(0.1)**	**0.0**	**(0.0)**	**0.1**	**0.2**	**0.1**
Mineral Soils	(0.0)	0.0	(0.1)	(0.0)	(0.0)	0.0	0.2	0.0
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	**(1.3)**	**(1.1)**	**(1.1)**	**(1.2)**	**(0.6)**	**(0.5)**	**(0.8)**	**(0.9)**
Mineral Soils	(2.1)	(1.9)	(1.8)	(2.0)	(1.4)	(1.1)	(1.3)	(1.4)
Organic Soils	0.8	0.8	0.7	0.8	0.8	0.5	0.5	0.5
Liming of Soils	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	**1.7**	**1.5**	**2.0**	**2.2**	**1.7**	**2.0**	**2.2**	**2.3**
Mineral Soils	(0.4)	(0.3)	0.0	(0.4)	(1.0)	(0.8)	(0.6)	(0.4)
Organic Soils	2.0	1.6	1.7	2.3	2.3	2.3	2.4	2.3
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.4
North Dakota	**(1.1)**	**(1.1)**	**(2.1)**	**(3.0)**	**(2.4)**	**(3.9)**	**(2.7)**	**(3.0)**
Mineral Soils	(1.1)	(1.1)	(2.2)	(3.0)	(2.5)	(4.0)	(2.8)	(3.1)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.2
Ohio	**(1.8)**	**(0.7)**	**(0.0)**	**(1.1)**	**(1.4)**	**(0.3)**	**(1.3)**	**(1.6)**
Mineral Soils	(2.7)	(1.7)	(0.9)	(2.0)	(2.3)	(1.0)	(2.1)	(2.3)
Organic Soils	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Liming of Soils	0.2	0.3	0.2	0.2	0.4	0.1	0.1	0.1
Urea	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oklahoma	**(0.9)**	**(0.7)**	**(0.7)**	**(0.6)**	**(0.2)**	**0.4**	**0.6**	**0.7**
Mineral Soils	(1.0)	(0.8)	(0.8)	(0.7)	(0.4)	0.2	0.3	0.5
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1
Urea	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1
Oregon	**(0.3)**	**(0.2)**	**(0.1)**	**(0.1)**	**(0.2)**	**(0.1)**	**(0.0)**	**(0.0)**
Mineral Soils	(0.5)	(0.3)	(0.3)	(0.3)	(0.4)	(0.3)	(0.2)	(0.2)
Organic Soils	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.1
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pennsylvania	**(2.1)**	**(2.2)**	**(1.5)**	**(2.1)**	**(1.1)**	**(0.9)**	**(1.1)**	**(1.3)**
Mineral Soils	(2.3)	(2.5)	(1.7)	(2.2)	(1.5)	(1.1)	(1.3)	(1.4)
Organic Soils	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.2	0.2	0.2	0.0	0.4	0.1	0.2	0.1
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhode Island	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mineral Soils	(0.0)	(0.0)	(0.0)	(0.0)	0.0	0.0	0.0	(0.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	**(0.2)**	**(0.2)**	**(0.0)**	**0.0**	**(0.3)**	**0.1**	**(0.0)**	**0.3**
Mineral Soils	(0.4)	(0.3)	(0.3)	(0.4)	(0.7)	(0.4)	(0.5)	(0.2)
Organic Soils	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.3	0.4	0.4	0.5	0.4	0.4
South Dakota	**(1.9)**	**(2.1)**	**(3.1)**	**(1.5)**	**(1.3)**	**(2.9)**	**(2.2)**	**(1.9)**
Mineral Soils	(2.0)	(2.2)	(3.2)	(1.5)	(1.4)	(3.0)	(2.3)	(2.0)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Tennessee	**(1.0)**	**(0.8)**	**(0.3)**	**(1.4)**	**(1.2)**	**(0.2)**	**(0.6)**	**(0.5)**
Mineral Soils	(1.3)	(1.2)	(1.0)	(1.6)	(1.3)	(0.4)	(0.8)	(0.6)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.2	0.2	0.5	0.1	0.1	0.1	0.1	0.1
Urea	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Texas	**(1.9)**	**(0.5)**	**(1.8)**	**(2.9)**	**1.6**	**2.1**	**2.4**	**2.4**
Mineral Soils	(2.1)	(0.7)	(1.9)	(2.9)	1.4	1.9	2.3	2.1
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.2	0.2	0.1	0.0	0.2	0.2	0.2	0.3
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utah	**(0.3)**	**(0.1)**	**(0.2)**	**(0.1)**	**0.1**	**(0.1)**	**0.1**	**0.2**
Mineral Soils	(0.3)	(0.2)	(0.2)	(0.2)	0.0	(0.2)	0.0	0.2
Organic Soils	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vermont	**(0.2)**	**(0.2)**	**(0.1)**	**(0.2)**	**(0.2)**	**(0.1)**	**(0.1)**	**(0.1)**
Mineral Soils	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)	(0.1)	(0.1)	(0.2)
Organic Soils	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	**(0.6)**	**(0.6)**	**(0.3)**	**(1.2)**	**(0.7)**	**(0.5)**	**(0.5)**	**(0.5)**
Mineral Soils	(0.9)	(0.9)	(0.7)	(1.2)	(1.0)	(0.8)	(0.8)	(0.7)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.3	0.3	0.4	0.0	0.2	0.2	0.3	0.2
Urea	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Washington	**(0.4)**	**(0.3)**	**(0.3)**	**(0.1)**	**0.7**	**(0.4)**	**(0.6)**	**(0.0)**
Mineral Soils	(0.7)	(0.5)	(0.6)	(0.3)	0.6	(0.5)	(0.7)	(0.2)
Organic Soils	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	**(0.4)**	**(0.4)**	**(0.4)**	**(0.5)**	**(0.4)**	**(0.1)**	**(0.1)**	**(0.1)**
Mineral Soils	(0.5)	(0.4)	(0.5)	(0.6)	(0.5)	(0.3)	(0.3)	(0.3)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Wisconsin	**2.1**	**2.4**	**2.8**	**1.8**	**3.3**	**2.1**	**2.4**	**2.4**
Mineral Soils	(1.7)	(1.0)	(0.5)	(1.1)	0.6	(0.9)	(0.5)	(0.3)
Organic Soils	3.7	3.3	3.2	3.0	2.5	2.8	2.7	2.5
Liming of Soils	0.1	0.1	0.1	0.0	0.2	0.2	0.1	0.1
Urea	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Wyoming	**(0.5)**	**(0.4)**	**(0.4)**	**(0.2)**	**(0.2)**	**(0.6)**	**(0.1)**	**(0.2)**
Mineral Soils	(0.5)	(0.4)	(0.4)	(0.2)	(0.2)	(0.6)	(0.1)	(0.2)
Organic Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liming of Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1] A portion of the carbonate lime data is considered proprietary information. These data are included in the national emission totals, but are not assigned to specific States. Therefore, some States have more emissions from carbonate lime applied to soils than reported in this table.

Appendix Table B-7 State-Level Areas by Cropland Systems, 1990, 1995, 2000, 2005, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*1,000 hectares*							
Alabama	**986.0**	**1,018.4**	**1,031.6**	**993.4**	**979.0**	**1,007.1**	**1,010.0**	**1,019.6**
USDA Conservation Reserve Program	55.7	73.9	88.1	111.3	109.2	102.7	99.1	98.0
Fallow	0.0	0.0	0.0	6.4	8.0	10.9	13.2	14.4
Grass Hay	63.0	81.7	95.1	142.9	168.6	177.5	170.3	180.7
Legume Hay	9.9	9.9	12.4	21.0	22.4	21.5	22.9	21.8
Hay/Pasture In Rotation	18.2	20.4	72.5	49.7	24.0	27.9	28.5	20.1
Irrigated	15.2	14.6	24.2	23.5	25.5	25.9	26.6	26.3
Low Residue	218.2	263.8	253.6	318.5	261.3	249.8	248.6	256.8
Other Crops	114.5	91.3	73.7	58.1	61.2	74.5	78.4	99.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	477.1	453.6	404.4	251.0	274.6	300.1	306.3	288.4
Small Grains	14.3	9.1	7.6	10.9	24.2	16.2	16.0	14.0
Arizona	**213.2**	**217.3**	**187.9**	**178.7**	**184.1**	**185.6**	**187.1**	**187.1**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	1.8	0.0	3.8	1.0	3.2	3.3	8.8
Grass Hay	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Hay/Pasture In Rotation	0.0	0.3	0.4	1.7	0.6	0.1	0.0	0.0
Irrigated	193.7	192.6	171.4	154.8	156.5	153.9	154.5	152.0
Low Residue	0.0	0.0	0.0	3.8	0.0	2.1	2.1	2.1
Other Crops	19.2	22.4	15.9	14.3	25.8	25.6	27.1	24.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Small Grains	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Arkansas	**2,903.0**	**2,918.5**	**2,902.1**	**2,907.9**	**2,902.6**	**2,893.3**	**2,868.5**	**2,864.8**
USDA Conservation Reserve Program	46.2	53.3	28.8	46.8	48.2	47.6	33.5	33.1
Fallow	6.4	0.0	15.6	20.1	51.2	50.4	56.0	47.7
Grass Hay	71.5	62.7	61.6	76.6	91.2	92.5	97.8	98.1
Legume Hay	6.9	7.7	6.2	11.5	11.9	12.5	12.5	12.5
Hay/Pasture In Rotation	1.9	12.9	13.5	11.8	0.9	5.5	2.4	2.0
Irrigated	1,161.0	1,365.2	1,685.2	1,792.1	1,723.6	1,770.4	1,812.1	1,782.2
Low Residue	204.4	202.4	144.4	64.5	47.9	37.6	31.4	22.6
Other Crops	57.4	59.9	49.1	28.9	59.5	41.5	37.4	46.3
Rice	568.3	536.5	404.2	452.0	573.0	524.5	469.6	497.7
Row Crops	731.7	559.3	436.5	336.7	263.7	280.0	278.6	279.2
Small Grains	47.4	58.7	56.8	67.0	31.5	30.7	37.2	43.5
California	**1,168.2**	**1,135.3**	**1,082.1**	**1,046.5**	**993.6**	**1,022.8**	**1,036.5**	**1,042.5**
USDA Conservation Reserve Program	12.0	29.9	38.6	37.4	8.6	8.6	8.6	8.6
Fallow	65.0	46.0	37.2	39.4	23.3	37.8	39.1	41.4
Grass Hay	25.7	20.5	21.0	16.8	20.4	18.9	18.4	21.0
Legume Hay	9.2	13.5	8.9	15.1	32.2	43.8	45.8	43.5
Hay/Pasture In Rotation	11.0	22.6	17.9	32.8	16.5	15.2	15.7	19.1
Irrigated	699.2	664.6	634.8	618.4	547.5	548.1	562.5	570.0
Low Residue	0.0	0.0	0.0	0.0	0.0	8.4	8.4	8.4
Other Crops	55.2	94.2	62.3	50.1	70.9	80.7	78.2	76.7
Rice	193.9	177.4	211.5	191.1	210.1	206.3	203.0	203.8
Row Crops	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0
Small Grains	97.0	66.6	49.8	43.7	64.0	55.0	56.8	49.9
Colorado	**3,840.6**	**3,843.6**	**3,771.9**	**3,726.6**	**3,642.8**	**3,636.2**	**3,627.2**	**3,620.2**
USDA Conservation Reserve Program	641.6	759.6	821.1	900.3	772.3	789.8	757.5	735.9
Fallow	1,757.7	1,578.2	1,529.6	1,342.6	1,308.3	1,438.2	1,408.1	1,361.7
Grass Hay	14.0	14.7	17.6	19.2	22.4	23.4	26.7	33.8
Legume Hay	22.7	24.8	16.2	21.7	25.5	31.3	36.0	34.6
Hay/Pasture In Rotation	10.4	9.2	9.1	6.6	12.9	19.9	12.0	11.0
Irrigated	857.5	817.2	859.1	832.2	819.7	775.2	779.7	763.0
Low Residue	0.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	230.4	196.6	198.3	162.4	309.8	258.2	297.4	280.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	75.9	63.0	89.3	156.1	138.9	100.2	91.7	145.6
Small Grains	229.8	378.7	231.6	285.5	233.0	200.1	218.0	254.7
Connecticut	**48.5**	**49.9**	**48.4**	**49.5**	**49.2**	**47.2**	**46.9**	**46.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Grass Hay	24.3	25.7	23.6	22.0	23.1	22.7	22.5	22.0
Legume Hay	5.5	6.7	10.5	10.4	9.4	9.5	9.4	10.0
Hay/Pasture In Rotation	2.0	1.4	2.2	2.3	2.1	0.3	0.3	0.7
Irrigated	0.0	0.0	0.2	0.2	1.0	0.8	0.8	0.8
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	2.3	0.7	0.0	1.6	0.3	0.2	0.2	0.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	14.3	15.2	12.0	12.9	13.3	13.7	12.2	11.9
Small Grains	0.0	0.2	0.0	0.0	0.0	0.0	1.3	1.3
Delaware	**114.0**	**114.8**	**114.8**	**110.0**	**106.5**	**108.2**	**108.0**	**108.0**
USDA Conservation Reserve Program	0.0	0.0	0.4	0.4	0.2	0.2	0.2	0.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	1.3	1.3	1.1	0.7	2.1	1.2	1.2	1.2
Legume Hay	1.1	0.5	0.5	1.1	0.7	0.7	0.8	0.8
Hay/Pasture In Rotation	2.5	1.3	0.8	2.9	0.8	1.3	0.8	0.6
Irrigated	5.6	7.9	15.4	21.1	22.3	24.2	27.0	29.7
Low Residue	0.2	0.7	0.4	0.4	0.0	0.0	0.0	0.0
Other Crops	1.6	1.3	0.4	1.2	1.4	2.1	2.1	2.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	100.8	94.9	93.1	79.5	75.4	72.7	69.5	62.4
Small Grains	0.9	6.7	2.8	2.7	3.7	5.8	6.6	10.7
Florida	**198.0**	**170.6**	**190.5**	**202.3**	**220.6**	**222.0**	**217.0**	**214.3**
USDA Conservation Reserve Program	8.6	9.8	8.4	10.6	10.3	7.5	7.4	7.4
Fallow	0.0	0.0	0.0	2.3	2.2	1.0	1.0	0.0
Grass Hay	12.6	15.5	22.7	32.5	43.6	44.9	39.6	38.6
Legume Hay	0.9	0.9	0.8	0.9	1.6	4.9	7.7	7.9
Hay/Pasture In Rotation	8.9	5.1	25.5	17.7	16.6	11.1	7.9	2.9
Irrigated	28.2	18.4	21.6	31.7	40.3	39.4	37.5	39.9
Low Residue	22.0	36.7	51.0	75.5	71.8	68.0	67.8	70.1
Other Crops	40.4	40.8	24.8	16.3	18.9	26.3	21.8	21.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	65.6	34.7	28.4	9.5	6.7	6.7	8.4	8.6
Small Grains	10.8	8.8	7.3	5.3	8.8	12.1	18.0	17.1
Georgia	**1,316.7**	**1,373.7**	**1,508.0**	**1,481.8**	**1,429.9**	**1,403.2**	**1,396.7**	**1,367.4**
USDA Conservation Reserve Program	29.1	38.3	41.6	43.7	53.1	49.8	49.0	48.2
Fallow	0.0	1.2	0.0	9.2	9.0	10.5	11.2	11.6
Grass Hay	43.9	45.5	81.1	110.9	109.4	125.8	132.1	127.6
Legume Hay	9.5	12.8	14.0	17.1	15.2	14.9	16.3	16.0
Hay/Pasture In Rotation	20.9	34.4	36.9	38.7	39.8	24.5	26.9	7.1
Irrigated	262.8	301.8	374.9	412.4	389.3	378.1	375.9	376.7
Low Residue	148.9	328.7	532.7	582.7	523.6	566.3	561.4	555.5
Other Crops	141.0	183.8	171.5	103.2	102.0	108.8	94.9	91.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	616.0	387.0	215.8	93.3	131.0	86.7	91.5	105.5
Small Grains	44.6	40.2	39.5	70.6	57.5	37.7	37.6	28.1
Idaho	**1,762.9**	**1,763.6**	**1,704.6**	**1,666.5**	**1,632.5**	**1,601.8**	**1,596.5**	**1,599.0**
USDA Conservation Reserve Program	249.7	314.1	275.5	273.3	234.9	171.5	173.1	174.2
Fallow	160.8	141.9	124.7	133.1	111.1	93.4	111.3	115.2
Grass Hay	28.2	35.1	30.6	28.6	39.4	37.3	36.0	36.1
Legume Hay	63.0	78.0	72.7	77.1	93.7	102.5	102.8	104.8
Hay/Pasture In Rotation	40.3	18.7	36.9	35.8	30.6	21.6	13.5	12.1
Irrigated	884.0	879.0	884.8	870.2	873.0	883.3	881.4	881.9
Low Residue	0.0	1.3	0.0	1.0	0.2	0.0	0.0	0.0
Other Crops	58.9	35.6	42.3	22.7	47.5	52.5	38.6	32.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.2	0.3	0.0	0.0	0.0	0.2	2.8	2.8
Small Grains	277.8	259.6	237.1	224.6	202.2	239.5	236.9	239.7
Illinois	**9,363.8**	**9,433.7**	**9,460.6**	**9,454.7**	**9,445.4**	**9,449.4**	**9,438.4**	**9,424.5**

USDA Conservation Reserve Program	172.6	289.5	216.5	240.5	223.9	202.6	169.4	156.2
Fallow	0.0	0.0	0.0	0.5	0.0	0.6	0.6	1.4
Grass Hay	43.0	41.2	51.2	87.8	91.2	92.9	90.5	92.1
Legume Hay	98.7	57.7	65.1	100.8	109.8	121.9	120.1	124.5
Hay/Pasture In Rotation	208.8	236.9	260.6	184.7	117.6	90.4	73.9	79.4
Irrigated	50.7	57.1	85.5	125.7	140.3	141.9	147.6	151.4
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	152.3	81.8	134.5	71.0	74.8	63.6	97.8	61.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	8,360.3	8,528.1	8,626.9	8,617.0	8,658.0	8,708.0	8,723.4	8,729.6
Small Grains	277.3	141.5	20.3	26.7	29.8	27.5	15.0	28.1
Indiana	**5,102.7**	**5,086.2**	**5,071.0**	**5,028.1**	**5,051.2**	**5,070.7**	**5,069.4**	**5,069.4**
USDA Conservation Reserve Program	114.4	153.4	82.2	64.4	47.9	38.5	35.8	34.7
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8
Grass Hay	52.0	66.3	101.0	94.9	89.2	76.8	79.1	78.7
Legume Hay	87.1	67.6	99.5	120.7	143.4	144.2	142.9	139.5
Hay/Pasture In Rotation	170.7	180.8	120.3	103.6	82.9	65.9	59.9	56.5
Irrigated	48.6	56.9	68.3	81.1	78.0	79.8	80.4	83.1
Low Residue	4.7	5.6	0.6	1.9	1.3	1.5	1.5	1.8
Other Crops	352.5	142.1	79.7	44.7	23.3	26.8	15.1	11.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4,154.1	4,349.6	4,483.0	4,480.3	4,569.9	4,621.2	4,639.9	4,640.2
Small Grains	118.7	64.0	36.4	36.7	15.3	16.1	14.2	22.9
Iowa	**10,557.6**	**10,590.7**	**10,550.6**	**10,579.7**	**10,577.7**	**10,625.9**	**10,607.8**	**10,532.8**
USDA Conservation Reserve Program	683.3	797.2	553.6	562.0	417.1	368.8	329.7	305.9
Fallow	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Grass Hay	73.2	127.8	124.4	168.4	137.7	153.5	157.1	152.0
Legume Hay	163.6	170.2	195.0	203.0	227.9	229.8	232.9	236.4
Hay/Pasture In Rotation	654.7	452.5	377.9	315.1	237.7	223.5	178.6	194.6
Irrigated	46.0	56.7	70.4	72.9	74.8	74.4	76.5	77.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	518.4	296.1	207.1	140.5	168.3	125.2	143.8	120.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	8,307.7	8,641.5	9,014.1	9,109.4	9,306.4	9,446.6	9,483.7	9,442.3
Small Grains	110.7	48.7	8.0	7.4	7.8	4.0	5.5	3.9
Kansas	**11,678.1**	**11,676.4**	**11,556.2**	**11,502.6**	**11,292.2**	**11,258.1**	**11,267.4**	**11,259.9**
USDA Conservation Reserve Program	795.8	1,153.6	1,027.4	1,136.6	1,098.4	872.6	853.6	799.2
Fallow	3,066.9	2,998.6	3,181.0	2,510.4	2,293.8	2,334.9	2,469.2	2,579.8
Grass Hay	150.8	223.0	266.2	286.0	241.6	251.5	261.5	288.4
Legume Hay	141.4	194.3	230.6	277.4	236.0	241.2	244.9	259.7
Hay/Pasture In Rotation	280.7	187.1	176.8	199.2	137.5	127.3	108.5	107.5
Irrigated	1,328.7	1,324.6	1,267.8	1,213.8	1,281.9	1,234.9	1,212.8	1,209.3
Low Residue	0.0	0.0	0.0	5.6	8.6	0.0	2.9	0.4
Other Crops	803.8	452.8	706.1	726.9	728.6	945.6	864.1	787.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,836.5	1,980.8	2,299.8	2,372.1	2,681.3	2,947.1	3,022.2	2,946.9
Small Grains	3,273.5	3,161.3	2,400.5	2,774.5	2,584.4	2,302.9	2,227.7	2,281.2
Kentucky	**1,994.4**	**2,009.0**	**2,113.0**	**2,137.4**	**2,135.0**	**2,207.5**	**2,213.3**	**2,194.6**
USDA Conservation Reserve Program	119.1	151.6	97.7	115.8	92.3	58.8	55.3	40.5
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	233.3	286.3	301.6	364.7	336.9	307.3	299.1	297.3
Legume Hay	230.2	258.8	315.3	388.5	378.1	355.4	344.4	345.0
Hay/Pasture In Rotation	225.5	199.2	231.9	138.7	141.1	148.9	145.7	77.3
Irrigated	2.8	6.8	28.0	25.2	14.9	14.2	14.0	15.0
Low Residue	46.7	66.8	47.1	30.9	23.0	15.4	14.7	20.3
Other Crops	90.7	58.7	39.2	32.2	42.4	74.3	67.9	57.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,001.9	931.6	1,011.9	998.6	1,057.2	1,135.2	1,202.6	1,247.8
Small Grains	44.2	49.3	40.3	42.9	49.0	98.1	69.6	93.8
Louisiana	**1,895.8**	**1,845.9**	**1,848.1**	**1,778.8**	**1,747.7**	**1,749.0**	**1,745.5**	**1,758.9**
USDA Conservation Reserve Program	4.1	6.1	13.4	27.9	47.0	41.2	41.2	41.5
Fallow	29.1	15.1	50.3	38.6	18.3	0.8	0.0	0.0
Grass Hay	41.2	40.1	36.5	65.4	83.4	72.7	72.0	75.6

Legume Hay	2.9	2.9	2.9	3.5	4.9	4.1	4.1	4.1
Hay/Pasture In Rotation	29.1	18.7	27.1	22.4	10.1	22.5	13.8	10.6
Irrigated	283.4	332.9	335.2	414.7	456.6	466.0	495.8	483.5
Low Residue	335.1	347.6	210.4	163.8	89.4	64.6	58.8	48.4
Other Crops	121.3	119.6	194.7	143.7	210.8	184.9	178.8	167.9
Rice	177.9	206.0	206.7	171.2	116.7	121.4	109.9	126.9
Row Crops	841.0	726.5	741.3	705.3	676.2	727.7	739.6	770.4
Small Grains	30.8	30.4	29.6	22.2	34.3	43.4	31.5	30.1
Maine	**153.3**	**150.9**	**150.8**	**145.8**	**143.2**	**136.7**	**134.8**	**133.5**
USDA Conservation Reserve Program	14.7	12.1	12.2	12.1	12.4	12.3	12.3	12.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	46.7	51.4	48.2	53.1	50.1	47.1	45.5	45.1
Legume Hay	26.9	30.1	30.6	32.4	30.2	30.1	30.1	29.7
Hay/Pasture In Rotation	15.2	5.6	13.0	5.9	9.4	0.6	4.3	4.3
Irrigated	2.2	0.4	1.1	1.9	1.8	1.8	1.8	1.8
Low Residue	23.2	24.7	28.3	16.8	16.9	13.3	17.6	9.9
Other Crops	8.5	9.5	3.2	6.6	6.9	16.1	10.1	10.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	3.6	6.8	3.5	2.6	2.6	2.0	2.0	1.7
Small Grains	12.3	10.3	10.9	14.5	12.8	13.4	11.2	18.7
Maryland	**487.0**	**498.6**	**495.2**	**498.2**	**486.5**	**493.7**	**491.7**	**490.5**
USDA Conservation Reserve Program	1.5	5.3	4.6	8.3	2.5	2.3	2.3	1.8
Fallow	0.0	0.0	0.0	0.6	2.8	2.9	0.8	0.8
Grass Hay	23.9	33.6	39.6	43.6	39.1	41.0	38.3	40.4
Legume Hay	14.6	17.7	20.9	26.6	24.5	29.9	31.0	30.6
Hay/Pasture In Rotation	35.1	31.8	42.2	55.3	32.0	21.6	18.4	16.1
Irrigated	3.6	4.5	9.0	13.5	19.0	20.2	21.2	23.5
Low Residue	9.1	9.6	1.1	0.2	0.0	0.0	0.0	0.0
Other Crops	30.0	18.8	21.8	11.0	11.5	8.2	6.8	9.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	329.3	331.9	325.1	324.5	339.1	354.9	358.5	337.9
Small Grains	39.7	45.5	30.8	14.7	15.9	12.7	14.3	30.1
Massachusetts	**52.7**	**58.5**	**57.7**	**54.4**	**53.8**	**52.7**	**51.7**	**51.4**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5
Grass Hay	24.4	27.9	30.1	28.0	27.8	27.2	27.4	27.3
Legume Hay	13.8	15.3	17.2	18.4	17.0	19.1	17.7	17.6
Hay/Pasture In Rotation	2.4	5.1	3.9	0.3	3.5	1.1	1.7	1.7
Irrigated	0.9	0.9	0.9	0.9	1.2	1.1	1.1	1.1
Low Residue	0.4	0.6	1.8	1.9	0.0	0.5	0.6	0.6
Other Crops	0.2	0.7	0.0	0.0	0.2	1.1	0.7	0.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	10.6	7.9	3.8	4.9	4.2	2.1	2.0	2.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**2,646.6**	**2,626.4**	**2,595.3**	**2,501.7**	**2,493.0**	**2,476.1**	**2,474.8**	**2,466.8**
USDA Conservation Reserve Program	59.0	111.8	94.4	57.3	45.1	31.4	27.0	25.3
Fallow	1.1	5.8	8.3	6.6	3.2	6.0	4.0	7.6
Grass Hay	133.7	134.1	132.4	111.6	111.4	100.5	99.2	99.6
Legume Hay	312.6	320.8	344.7	353.5	326.4	310.7	307.9	304.6
Hay/Pasture In Rotation	257.1	248.5	185.9	162.5	150.5	102.6	91.2	72.1
Irrigated	94.2	104.6	129.2	130.0	140.5	148.5	149.2	154.8
Low Residue	7.9	11.7	4.0	1.3	4.4	1.6	3.7	2.9
Other Crops	180.7	136.0	109.1	81.0	53.6	71.1	67.8	72.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,484.9	1,476.1	1,564.7	1,575.0	1,615.5	1,668.3	1,704.0	1,697.6
Small Grains	115.4	77.0	22.5	22.9	42.3	35.3	20.6	29.5
Minnesota	**7,657.7**	**7,660.6**	**7,579.4**	**7,559.9**	**7,519.2**	**7,499.3**	**7,496.3**	**7,444.0**
USDA Conservation Reserve Program	511.6	636.7	486.2	524.9	446.0	328.3	291.6	221.3
Fallow	10.3	28.7	28.9	12.1	9.6	17.5	7.1	6.7
Grass Hay	133.3	172.4	179.8	204.7	210.6	196.4	200.9	201.5
Legume Hay	296.1	299.7	315.4	365.6	411.6	388.7	378.7	385.8
Hay/Pasture In Rotation	609.4	457.8	410.7	412.4	319.3	293.9	264.7	255.4
Irrigated	108.4	105.0	97.3	123.6	130.8	141.2	148.5	150.5

Low Residue	43.5	86.8	18.9	16.8	10.2	12.3	10.8	12.6
Other Crops	489.8	413.6	456.3	364.6	360.0	402.8	421.4	346.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4,021.0	4,400.9	4,794.8	4,993.6	5,176.2	5,419.1	5,417.5	5,550.8
Small Grains	1,434.4	1,058.9	791.1	541.6	444.8	299.1	355.1	313.1
Mississippi	**2,086.7**	**2,096.2**	**2,125.6**	**2,095.5**	**2,098.7**	**2,101.3**	**2,115.8**	**2,110.3**
USDA Conservation Reserve Program	115.5	182.3	189.2	216.6	228.1	209.6	212.1	206.2
Fallow	0.0	0.0	3.6	13.8	1.9	12.4	12.9	15.0
Grass Hay	21.7	56.8	84.0	123.3	118.4	117.7	117.9	116.3
Legume Hay	2.8	6.7	6.1	9.4	12.3	10.7	10.5	9.9
Hay/Pasture In Rotation	37.2	35.2	40.6	14.5	20.8	10.2	12.9	22.5
Irrigated	324.4	385.2	521.0	599.0	693.5	706.3	710.6	721.9
Low Residue	455.9	470.8	417.4	341.6	161.8	142.0	144.3	121.2
Other Crops	237.0	154.6	95.6	63.6	37.3	51.0	53.7	52.2
Rice	94.4	113.9	61.1	81.3	59.0	40.2	50.5	41.2
Row Crops	755.6	664.4	698.2	619.9	745.7	778.1	769.1	778.9
Small Grains	42.4	26.3	8.9	12.4	20.0	23.0	21.2	25.0
Missouri	**5,611.6**	**5,806.1**	**5,771.3**	**5,754.9**	**5,839.9**	**5,976.2**	**5,991.8**	**6,003.5**
USDA Conservation Reserve Program	461.0	649.5	556.4	571.3	480.2	373.4	331.1	309.0
Fallow	0.0	1.2	5.5	1.2	10.4	3.8	2.8	3.7
Grass Hay	370.9	601.0	625.1	668.9	717.6	715.5	730.6	749.4
Legume Hay	273.0	343.5	422.7	459.5	472.4	468.2	457.5	460.7
Hay/Pasture In Rotation	306.6	292.1	197.6	180.7	187.1	203.5	164.5	112.0
Irrigated	286.4	386.2	457.0	473.9	489.8	521.8	531.8	540.0
Low Residue	85.5	78.6	52.5	49.5	38.7	21.8	23.5	19.0
Other Crops	297.3	227.9	180.9	78.2	102.3	175.7	164.3	144.9
Rice	36.4	35.3	44.0	94.6	96.7	74.8	64.5	56.3
Row Crops	3,151.6	2,898.1	3,082.2	3,061.7	3,164.0	3,343.2	3,435.0	3,507.3
Small Grains	342.8	292.5	147.4	115.5	80.5	74.6	86.2	101.3
Montana	**6,606.2**	**6,663.2**	**6,575.8**	**6,547.9**	**6,449.6**	**6,356.9**	**6,329.7**	**6,267.3**
USDA Conservation Reserve Program	930.9	1,118.7	1,228.9	1,292.2	1,176.6	736.2	635.0	530.3
Fallow	3,142.1	3,074.5	2,757.8	2,668.2	2,685.8	2,439.7	2,449.8	2,255.6
Grass Hay	193.3	180.5	165.6	240.4	273.6	301.6	333.7	337.9
Legume Hay	256.9	270.0	256.1	410.9	440.9	505.7	527.1	539.9
Hay/Pasture In Rotation	92.4	113.2	196.8	126.0	135.2	135.0	96.9	127.4
Irrigated	752.9	788.9	828.7	786.6	756.2	741.3	724.7	728.2
Low Residue	0.0	0.0	0.0	2.2	2.2	3.7	2.3	13.2
Other Crops	279.7	226.7	261.0	126.7	186.4	394.7	405.1	326.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.9	1.4	2.8	4.1	4.5	5.3	8.3	8.4
Small Grains	955.1	889.3	878.3	890.6	788.1	1,093.6	1,146.9	1,399.8
Nebraska	**7,891.0**	**7,952.2**	**7,931.9**	**7,943.7**	**7,948.3**	**7,968.6**	**7,970.0**	**7,959.7**
USDA Conservation Reserve Program	418.2	541.6	418.7	453.3	380.0	280.4	258.3	229.9
Fallow	823.3	808.7	933.6	809.3	733.0	747.2	748.5	759.4
Grass Hay	76.4	74.4	109.5	112.2	113.3	103.5	112.0	110.9
Legume Hay	244.2	262.8	276.7	269.0	217.8	227.0	226.0	231.1
Hay/Pasture In Rotation	213.6	240.2	195.8	211.2	141.5	124.4	93.5	87.2
Irrigated	2,714.9	2,827.1	2,938.0	3,115.0	3,256.3	3,265.9	3,287.6	3,276.5
Low Residue	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	518.4	343.7	292.5	218.6	295.8	263.8	199.3	253.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2,309.6	2,416.1	2,574.1	2,503.1	2,622.5	2,767.9	2,880.0	2,866.9
Small Grains	571.8	437.5	193.1	252.0	187.9	188.5	164.9	144.6
Nevada	**268.5**	**253.5**	**246.6**	**240.9**	**223.2**	**222.6**	**220.6**	**219.3**
USDA Conservation Reserve Program	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.0
Grass Hay	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Legume Hay	0.4	0.6	0.4	0.6	0.0	0.1	0.1	0.1
Hay/Pasture In Rotation	0.0	0.1	2.6	0.1	0.0	0.2	0.2	0.2
Irrigated	250.5	231.2	228.2	236.4	218.6	215.0	213.1	213.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	17.4	20.7	15.4	3.7	4.5	7.2	6.5	5.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5

Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**39.4**	**39.0**	**39.8**	**40.9**	**38.4**	**38.3**	**38.6**	**38.6**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	26.2	25.2	26.7	25.8	25.4	24.9	25.1	24.8
Legume Hay	6.5	7.3	7.3	8.5	7.6	7.6	7.6	7.6
Hay/Pasture In Rotation	0.5	1.2	0.3	2.1	2.0	0.6	0.4	0.5
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	6.2	5.4	5.5	4.4	3.4	5.2	5.4	5.7
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**111.3**	**112.9**	**111.4**	**100.8**	**98.0**	**96.1**	**95.8**	**95.3**
USDA Conservation Reserve Program	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	1.9	2.3	1.6	2.6	1.3
Grass Hay	9.1	12.5	14.3	10.3	10.4	11.5	11.9	13.4
Legume Hay	7.1	13.4	14.3	12.9	12.7	13.6	13.1	13.7
Hay/Pasture In Rotation	16.8	5.9	14.1	18.2	6.8	5.0	4.4	2.5
Irrigated	0.4	0.4	1.8	3.8	5.0	5.0	5.0	4.9
Low Residue	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Other Crops	7.9	7.3	3.7	4.4	5.5	4.1	4.5	5.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	64.8	69.5	58.2	48.0	50.3	54.6	52.6	52.8
Small Grains	5.2	3.7	4.6	1.3	4.7	0.7	1.8	1.8
New Mexico	**750.9**	**744.2**	**713.6**	**677.5**	**620.9**	**580.1**	**562.5**	**554.9**
USDA Conservation Reserve Program	182.0	186.4	253.2	247.3	206.4	163.6	163.6	160.4
Fallow	6.2	16.5	7.3	13.6	19.9	39.3	33.1	38.8
Grass Hay	4.4	5.3	2.2	1.0	1.0	1.9	1.9	1.9
Legume Hay	2.6	5.4	1.1	0.6	1.1	13.4	13.4	13.4
Hay/Pasture In Rotation	1.1	0.7	5.5	0.6	0.6	4.9	1.9	0.6
Irrigated	269.3	251.9	253.0	232.5	211.9	187.4	187.7	187.2
Low Residue	4.0	2.7	0.0	1.7	0.6	0.6	0.6	2.7
Other Crops	46.8	34.3	46.9	15.0	27.7	47.7	39.8	31.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	61.7	49.0	25.5	36.8	17.0	13.8	14.0	15.9
Small Grains	172.7	192.0	118.9	128.4	134.6	107.5	106.6	102.4
New York	**1,685.4**	**1,688.2**	**1,708.0**	**1,655.9**	**1,612.1**	**1,590.9**	**1,582.2**	**1,581.3**
USDA Conservation Reserve Program	14.8	20.7	18.4	17.5	16.3	7.3	7.3	7.3
Fallow	4.9	1.0	0.0	2.1	6.9	9.0	7.6	8.7
Grass Hay	376.9	384.1	417.9	402.4	356.2	352.9	345.6	349.8
Legume Hay	390.4	430.3	513.4	511.2	478.3	475.6	469.1	471.4
Hay/Pasture In Rotation	386.1	367.2	331.2	302.9	254.7	204.5	191.5	186.0
Irrigated	1.2	0.4	1.0	0.6	0.6	0.0	0.0	0.0
Low Residue	4.8	4.6	2.1	0.0	0.0	0.0	0.0	0.0
Other Crops	107.5	72.3	64.2	32.3	68.6	60.2	76.8	68.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	367.8	384.7	337.0	361.3	411.9	473.1	478.6	481.1
Small Grains	30.8	22.8	22.9	25.6	18.7	8.2	5.7	8.9
North Carolina	**1,638.5**	**1,629.3**	**1,681.8**	**1,623.6**	**1,569.6**	**1,569.1**	**1,578.5**	**1,554.9**
USDA Conservation Reserve Program	11.9	21.5	15.9	18.0	19.8	13.3	14.8	14.7
Fallow	3.6	4.7	0.3	15.7	12.8	14.9	15.0	17.4
Grass Hay	60.0	71.2	140.8	150.9	155.0	160.2	160.8	165.9
Legume Hay	20.2	10.8	15.4	17.4	16.0	17.5	19.2	17.6
Hay/Pasture In Rotation	34.3	48.8	50.4	59.7	33.6	27.7	30.2	16.4
Irrigated	87.4	85.0	97.0	77.4	42.8	40.9	39.6	41.0
Low Residue	181.5	337.6	402.6	456.2	291.2	290.6	336.3	321.9
Other Crops	118.6	150.7	212.8	157.9	175.4	227.3	205.3	208.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,064.3	806.3	682.1	636.0	748.1	676.3	645.1	633.4
Small Grains	56.9	92.5	64.5	34.4	74.8	100.4	112.2	117.9
North Dakota	**7,294.9**	**7,347.8**	**7,268.6**	**7,148.8**	**7,016.0**	**6,884.8**	**6,841.9**	**6,789.1**

USDA Conservation Reserve Program	712.0	1,035.7	1,164.5	1,214.7	929.5	525.4	447.7	392.9
Fallow	807.3	749.9	462.8	229.0	116.2	84.5	76.7	84.6
Grass Hay	196.8	228.0	250.5	285.3	307.8	290.4	287.6	286.6
Legume Hay	347.5	298.3	285.0	358.5	344.2	355.3	356.7	347.0
Hay/Pasture In Rotation	193.5	268.4	254.0	235.2	141.9	151.1	146.1	195.2
Irrigated	47.7	46.8	48.8	50.1	51.6	57.1	55.5	56.5
Low Residue	13.9	10.1	2.2	1.0	5.1	0.0	1.0	0.0
Other Crops	778.3	496.9	644.2	414.1	501.2	1,086.0	1,071.4	920.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	497.1	629.0	622.2	1,323.1	1,762.3	1,949.1	2,089.6	2,178.8
Small Grains	3,700.9	3,584.8	3,534.4	3,037.9	2,856.0	2,385.9	2,309.8	2,327.1
Ohio	**4,326.5**	**4,349.1**	**4,282.8**	**4,259.4**	**4,214.4**	**4,206.7**	**4,220.6**	**4,222.0**
USDA Conservation Reserve Program	74.4	130.5	89.4	63.7	71.6	45.1	34.5	32.2
Fallow	0.0	0.0	0.0	0.0	1.2	1.2	0.4	0.5
Grass Hay	123.2	149.7	187.9	197.5	187.6	181.2	189.4	192.5
Legume Hay	144.4	163.3	223.9	255.6	258.0	242.7	245.2	249.0
Hay/Pasture In Rotation	310.0	342.5	189.0	212.4	112.4	129.7	113.1	87.4
Irrigated	5.0	5.6	3.5	3.4	4.8	4.7	4.7	4.7
Low Residue	4.7	5.1	3.3	2.0	1.1	0.2	0.5	0.3
Other Crops	251.4	171.4	145.3	128.1	75.8	69.0	67.5	72.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	3,167.1	3,147.2	3,419.0	3,368.6	3,479.8	3,519.1	3,553.3	3,561.2
Small Grains	246.2	233.9	21.5	28.0	22.3	13.6	12.1	21.8
Oklahoma	**4,449.9**	**4,321.7**	**3,993.0**	**3,918.1**	**3,825.8**	**3,768.1**	**3,766.5**	**3,733.1**
USDA Conservation Reserve Program	372.7	495.6	400.6	410.4	339.0	320.5	310.8	291.7
Fallow	40.1	38.9	28.6	30.6	24.6	46.2	75.1	93.2
Grass Hay	52.4	61.0	73.3	91.5	125.7	129.0	133.5	132.7
Legume Hay	38.3	52.2	72.6	108.6	115.6	141.7	141.8	140.5
Hay/Pasture In Rotation	58.5	40.3	108.7	82.0	106.6	41.4	44.9	33.8
Irrigated	284.4	272.6	267.5	268.3	244.0	243.2	236.9	236.8
Low Residue	144.4	146.2	94.8	25.9	45.2	33.8	37.9	32.7
Other Crops	78.9	46.3	67.9	27.3	40.0	63.9	52.8	71.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	223.1	153.3	120.7	114.9	141.8	132.6	102.1	100.7
Small Grains	3,157.2	3,015.3	2,758.3	2,758.6	2,643.3	2,615.9	2,630.8	2,599.5
Oregon	**1,258.7**	**1,258.8**	**1,240.7**	**1,261.6**	**1,239.8**	**1,252.4**	**1,254.3**	**1,278.8**
USDA Conservation Reserve Program	196.2	199.7	173.2	189.0	197.1	190.9	194.5	195.5
Fallow	394.9	423.9	347.1	349.4	327.4	369.6	385.5	400.2
Grass Hay	20.0	24.8	18.3	16.1	23.2	25.2	25.4	23.9
Legume Hay	20.6	22.8	20.3	24.9	28.0	28.1	27.7	27.5
Hay/Pasture In Rotation	12.5	12.7	22.9	17.7	9.0	7.4	4.3	13.6
Irrigated	381.6	381.3	394.2	433.6	405.3	402.6	412.2	436.7
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	26.9	14.5	69.8	8.1	5.6	17.9	5.3	1.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.5	2.3	1.1	0.2	0.2	0.2	0.2	0.2
Small Grains	204.3	176.8	193.8	222.6	243.9	210.5	199.3	179.6
Pennsylvania	**1,752.9**	**1,821.2**	**1,790.3**	**1,760.3**	**1,734.8**	**1,734.9**	**1,721.8**	**1,721.6**
USDA Conservation Reserve Program	20.3	31.2	13.3	11.5	6.5	7.3	4.3	3.5
Fallow	0.0	0.0	0.3	1.0	1.4	4.1	4.0	5.6
Grass Hay	289.2	318.6	320.9	348.4	322.2	331.7	333.7	335.4
Legume Hay	214.1	218.2	258.5	321.6	290.9	284.2	285.4	291.0
Hay/Pasture In Rotation	397.2	421.9	440.6	337.3	320.9	222.6	190.7	212.4
Irrigated	0.5	0.6	0.9	2.6	2.0	2.0	2.0	2.0
Low Residue	2.0	1.9	0.2	0.6	0.5	1.1	0.0	0.6
Other Crops	164.2	153.0	159.1	111.1	83.7	83.6	55.8	52.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	588.0	613.6	576.5	610.6	678.6	777.7	831.4	800.3
Small Grains	77.4	62.1	20.0	15.6	28.0	20.7	14.3	17.9
Rhode Island	**3.5**	**3.1**	**3.0**	**3.2**	**3.3**	**3.2**	**3.8**	**3.8**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	1.7	1.6	1.5	1.6	1.5	1.5	2.0	2.0

Legume Hay	0.6	0.7	0.6	0.4	0.4	0.5	0.5	0.7
Hay/Pasture In Rotation	0.0	0.0	0.0	0.5	0.3	0.2	0.2	0.0
Irrigated	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.7	0.4	0.4	0.3	0.4	0.6	0.6	0.6
Small Grains	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.2
South Carolina	**794.0**	**818.9**	**882.0**	**867.7**	**843.5**	**844.4**	**830.3**	**821.4**
USDA Conservation Reserve Program	16.3	23.4	33.0	32.2	30.0	27.7	27.3	27.0
Fallow	0.4	3.4	4.9	13.7	2.1	3.6	2.2	2.7
Grass Hay	29.4	40.1	58.9	77.7	96.3	100.5	97.2	94.4
Legume Hay	2.3	6.6	6.8	8.1	6.3	8.5	8.4	8.3
Hay/Pasture In Rotation	16.8	10.8	23.7	12.9	11.6	5.1	7.3	9.9
Irrigated	22.6	29.1	38.2	36.6	47.8	44.6	43.9	44.4
Low Residue	76.0	92.9	163.3	166.6	106.8	130.2	156.3	154.9
Other Crops	49.6	78.3	87.2	66.2	92.4	146.3	144.5	151.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	523.3	470.7	440.6	430.7	430.1	346.1	304.8	273.3
Small Grains	57.4	63.6	25.5	22.9	20.1	31.8	38.4	55.4
South Dakota	**7,087.9**	**7,213.3**	**7,189.9**	**7,193.1**	**7,162.0**	**7,146.1**	**7,166.0**	**7,165.5**
USDA Conservation Reserve Program	493.1	712.2	479.3	515.7	326.9	185.5	153.3	135.3
Fallow	668.8	629.0	392.8	276.9	206.7	240.4	206.8	192.9
Grass Hay	180.8	250.1	289.7	281.0	283.8	256.4	256.9	269.7
Legume Hay	441.2	477.0	421.5	551.0	582.1	593.3	603.3	609.9
Hay/Pasture In Rotation	366.3	382.7	411.3	440.0	270.0	202.7	169.2	203.7
Irrigated	184.7	182.6	171.3	169.6	143.7	146.9	147.3	153.0
Low Residue	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	794.9	517.8	695.8	235.7	363.0	325.7	348.2	274.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2,030.9	2,646.3	3,244.1	3,810.8	3,949.1	4,398.3	4,518.5	4,557.5
Small Grains	1,926.4	1,415.7	1,084.1	912.4	1,036.7	797.0	762.5	769.5
Tennessee	**1,712.7**	**1,699.4**	**1,736.8**	**1,691.5**	**1,722.3**	**1,756.3**	**1,746.0**	**1,734.9**
USDA Conservation Reserve Program	111.5	147.0	76.8	85.5	66.9	58.0	50.5	43.3
Fallow	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2
Grass Hay	190.2	222.4	262.7	286.2	298.9	271.2	265.6	265.8
Legume Hay	101.8	136.1	190.3	215.4	203.1	194.7	186.0	183.6
Hay/Pasture In Rotation	116.8	118.0	113.5	52.0	58.4	77.7	57.4	21.0
Irrigated	1.6	2.8	8.9	17.4	30.1	33.3	35.0	38.0
Low Residue	185.2	266.6	224.6	268.2	168.4	150.0	143.0	120.7
Other Crops	71.3	53.1	68.4	29.2	58.5	57.0	57.5	77.8
Rice	0.0	0.0	0.0	0.3	1.0	0.0	0.0	0.0
Row Crops	902.4	734.1	776.4	701.1	799.2	862.4	885.9	931.2
Small Grains	32.0	19.2	15.3	36.3	37.6	51.9	64.8	53.4
Texas	**11,963.2**	**11,670.8**	**11,121.4**	**10,685.9**	**10,235.5**	**10,137.3**	**10,132.8**	**10,057.8**
USDA Conservation Reserve Program	1,217.8	1,609.4	1,524.6	1,553.0	1,313.9	1,241.5	1,201.0	1,144.5
Fallow	248.8	343.1	211.1	171.2	257.4	293.1	364.3	413.5
Grass Hay	118.2	83.2	98.8	166.9	266.3	300.1	325.5	331.4
Legume Hay	13.2	17.1	14.0	26.1	44.8	50.7	51.5	49.8
Hay/Pasture In Rotation	75.1	88.7	73.2	85.4	130.2	121.4	101.3	66.4
Irrigated	2,895.4	2,764.9	2,841.5	2,750.1	2,468.1	2,400.2	2,385.3	2,329.6
Low Residue	2,001.2	1,863.1	1,722.7	1,553.4	1,407.2	1,550.4	1,610.1	1,559.9
Other Crops	543.8	451.4	570.1	465.7	696.0	832.2	817.6	789.4
Rice	119.0	135.4	45.3	47.7	22.3	29.0	12.3	28.4
Row Crops	1,517.6	1,520.9	1,513.7	1,297.1	1,299.6	1,197.6	1,210.8	1,302.4
Small Grains	3,213.1	2,793.7	2,506.3	2,569.3	2,329.9	2,121.3	2,053.1	2,042.6
Utah	**599.7**	**569.0**	**574.6**	**552.1**	**559.4**	**572.2**	**570.3**	**570.6**
USDA Conservation Reserve Program	53.4	65.4	86.1	80.5	73.0	70.9	70.9	70.9
Fallow	74.3	78.2	45.0	31.9	32.1	29.6	27.7	45.3
Grass Hay	1.9	0.9	1.3	0.8	1.1	1.4	1.5	1.4
Legume Hay	12.4	13.9	12.2	10.1	9.3	12.6	12.8	11.9
Hay/Pasture In Rotation	10.1	2.1	6.9	7.7	8.7	1.2	0.1	2.0
Irrigated	393.8	381.2	393.8	378.5	378.7	390.6	388.1	389.9

Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	39.7	17.7	20.7	26.4	41.9	51.0	42.4	39.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.9	0.0	0.6	0.8	1.8	6.3	7.1
Small Grains	14.0	8.9	8.7	15.6	13.8	13.2	20.4	2.8
Vermont	**223.6**	**219.1**	**211.4**	**211.2**	**205.3**	**202.0**	**200.7**	**201.4**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.1	1.9	0.8	0.3	0.0	0.3
Grass Hay	94.8	86.3	78.9	73.2	73.7	67.7	69.7	69.1
Legume Hay	70.9	78.7	72.4	69.3	74.1	72.2	69.1	68.0
Hay/Pasture In Rotation	23.0	20.8	26.8	31.0	20.5	22.1	20.5	20.3
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.0	0.4	0.7	1.0	1.0	1.6	1.2	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	33.3	32.9	32.5	34.4	35.2	38.1	40.2	43.3
Small Grains	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Virginia	**946.1**	**993.4**	**1,016.2**	**1,006.1**	**997.3**	**1,008.7**	**1,006.7**	**1,004.4**
USDA Conservation Reserve Program	7.6	12.3	9.3	7.8	8.0	8.6	8.5	8.5
Fallow	0.0	0.0	0.0	0.0	1.1	2.0	1.9	1.9
Grass Hay	218.7	288.7	275.0	290.1	288.2	283.0	283.5	283.3
Legume Hay	92.1	101.4	143.3	164.1	173.8	170.7	170.7	172.1
Hay/Pasture In Rotation	88.8	70.5	84.7	62.0	47.8	37.1	33.6	23.1
Irrigated	31.9	35.3	40.0	31.2	24.3	23.2	23.7	23.0
Low Residue	42.8	73.8	82.3	54.5	35.6	36.7	46.7	45.4
Other Crops	87.0	58.1	66.6	58.0	49.7	41.3	46.8	55.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	324.8	279.4	275.1	259.2	301.7	347.0	331.4	334.6
Small Grains	52.3	74.1	39.9	79.3	67.1	59.0	59.9	57.5
Washington	**2,170.0**	**2,177.2**	**2,154.1**	**2,113.7**	**2,075.3**	**2,049.7**	**2,050.3**	**2,054.1**
USDA Conservation Reserve Program	292.7	409.8	401.8	517.0	537.9	504.1	479.4	442.8
Fallow	1,136.7	1,174.9	1,047.6	994.3	952.4	885.3	893.9	938.2
Grass Hay	43.5	49.1	39.9	36.7	32.6	37.4	37.2	37.2
Legume Hay	31.1	35.7	29.8	26.9	45.4	42.3	46.6	47.7
Hay/Pasture In Rotation	21.4	14.7	16.2	22.6	14.8	11.8	11.1	24.1
Irrigated	165.4	167.9	167.2	157.5	157.5	162.0	161.6	160.7
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	100.9	30.3	88.7	6.1	30.3	89.5	111.0	132.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.3	2.5	1.8	9.2	5.6	2.2	2.2	2.0
Small Grains	377.0	292.3	361.1	343.2	298.7	315.3	307.4	269.0
West Virginia	**289.9**	**288.4**	**305.5**	**270.7**	**241.0**	**226.3**	**222.0**	**219.6**
USDA Conservation Reserve Program	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	150.0	149.7	154.9	139.8	123.9	107.2	104.0	102.7
Legume Hay	75.7	80.2	100.4	94.8	78.9	74.2	76.9	76.1
Hay/Pasture In Rotation	13.4	9.3	12.2	8.0	5.9	10.3	10.6	7.6
Irrigated	0.0	0.0	0.9	0.4	0.0	0.0	0.0	0.0
Low Residue	2.1	2.3	1.3	0.6	0.0	0.0	0.0	0.0
Other Crops	2.7	3.8	0.6	0.4	0.9	3.4	2.2	1.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	45.8	40.1	32.8	26.6	31.4	31.1	28.4	31.4
Small Grains	0.0	3.0	2.4	0.0	0.0	0.0	0.0	0.0
Wisconsin	**3,569.0**	**3,578.3**	**3,507.8**	**3,458.1**	**3,457.0**	**3,482.6**	**3,475.7**	**3,472.9**
USDA Conservation Reserve Program	164.5	240.5	192.0	189.3	127.4	74.3	65.4	64.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	116.8	137.6	136.9	136.9	138.9	126.4	120.7	120.0
Legume Hay	486.2	407.0	392.4	432.9	446.3	420.8	405.3	401.9
Hay/Pasture In Rotation	1,061.0	984.6	872.9	750.0	632.5	544.3	530.6	554.3
Irrigated	18.8	20.0	21.5	33.8	42.3	44.1	45.8	44.0
Low Residue	5.8	3.9	3.0	2.6	0.0	0.0	0.0	0.0
Other Crops	419.7	370.4	278.8	260.0	202.8	189.0	187.4	135.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,212.5	1,351.1	1,586.2	1,633.8	1,847.0	2,053.2	2,098.3	2,134.6

Small Grains	83.8	63.3	24.2	18.8	19.7	30.4	22.1	18.9
Wyoming	**872.4**	**850.7**	**876.3**	**856.4**	**837.0**	**827.6**	**823.3**	**825.8**
USDA Conservation Reserve Program	81.9	100.0	113.0	107.0	96.0	72.2	71.8	71.2
Fallow	162.6	159.8	124.3	112.7	110.6	104.2	99.3	102.7
Grass Hay	33.6	41.0	47.3	57.0	58.0	57.1	54.6	56.2
Legume Hay	69.0	65.6	59.4	59.3	85.5	89.1	91.3	99.1
Hay/Pasture In Rotation	11.6	10.8	38.2	12.1	7.2	14.3	15.4	11.6
Irrigated	461.6	442.4	454.2	469.8	446.8	455.7	451.3	453.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	23.9	13.4	14.9	17.5	20.9	21.0	18.3	16.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.3	0.4	2.3	0.8	0.6	2.1	4.6	4.0
Small Grains	27.9	17.4	22.5	20.1	11.4	12.0	16.8	10.9

Note: Estimates are only for land area that is included in Tier 3 method. Other areas are only estimated in aggregate at national scale and so State-level data are not available. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method.

Appendix Table B-8 State-Level Estimates by Cropland Systems of Total Annual Direct Nitrous Oxide Emissions, 1990, 1995, 2000, 2005, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*Gg CO2 eq.*							
Alabama	**888.7**	**938.4**	**885.4**	**893.6**	**847.6**	**947.5**	**958.4**	**984.8**
USDA Conservation Reserve Program	28.2	38.3	39.8	59.7	51.0	53.2	47.7	50.3
Fallow	0.0	0.0	0.0	4.3	8.0	7.9	10.2	10.0
Grass Hay	47.1	66.2	74.4	126.8	135.4	161.7	144.1	168.7
Legume Hay	8.7	10.6	9.8	18.7	19.7	20.6	21.4	21.0
Hay/Pasture In Rotation	17.0	22.9	55.9	45.6	20.0	28.8	29.5	26.3
Irrigated	14.6	13.4	22.8	23.5	25.2	24.2	25.9	25.4
Low Residue	203.7	248.8	220.5	299.1	232.7	232.6	235.1	246.9
Other Crops	78.4	60.6	44.7	40.9	46.2	59.9	69.4	88.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	477.2	467.6	410.1	265.8	290.1	342.2	359.0	332.7
Small Grains	13.9	9.9	7.4	9.3	19.4	16.4	16.1	15.0
Arizona	**234.3**	**230.7**	**214.4**	**221.9**	**216.6**	**245.6**	**246.2**	**235.1**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	1.6	0.0	8.1	1.0	2.7	2.6	7.5
Grass Hay	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
Hay/Pasture In Rotation	0.0	0.3	0.3	2.2	0.4	0.1	0.0	0.0
Irrigated	221.6	218.2	201.8	196.6	199.7	218.2	215.9	204.7
Low Residue	0.0	0.0	0.0	4.4	0.0	2.5	2.7	2.7
Other Crops	12.5	10.4	12.3	10.1	15.2	21.5	24.9	19.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.2	0.1	0.2	0.1	0.2
Small Grains	0.1	0.2	0.0	0.3	0.0	0.0	0.0	0.0
Arkansas	**3,946.9**	**3,954.6**	**4,158.1**	**3,752.3**	**3,922.4**	**4,046.8**	**4,194.2**	**4,054.5**
USDA Conservation Reserve Program	18.4	20.5	12.8	21.4	19.0	22.7	17.0	15.7
Fallow	8.7	0.0	21.0	24.1	60.8	62.8	75.3	59.6
Grass Hay	59.5	47.6	53.8	59.5	73.2	82.8	96.0	89.5
Legume Hay	6.3	6.5	5.1	9.2	9.5	10.7	12.0	10.7
Hay/Pasture In Rotation	2.1	19.8	11.9	8.4	0.6	4.5	2.2	1.5
Irrigated	1,596.7	1,881.0	2,411.4	2,357.5	2,377.7	2,501.5	2,646.0	2,569.9
Low Residue	286.2	284.5	223.8	77.8	59.5	54.6	42.9	28.5
Other Crops	60.2	61.0	59.8	23.4	48.6	59.4	50.5	56.8
Rice	883.7	817.9	650.9	660.5	878.4	801.4	761.0	748.7
Row Crops	968.2	744.8	639.0	434.7	355.5	409.0	438.1	412.4
Small Grains	57.0	71.1	68.7	75.8	39.7	37.4	53.1	61.3
California	**1,140.1**	**1,089.9**	**1,055.6**	**1,018.0**	**1,003.1**	**990.5**	**1,042.4**	**1,005.3**
USDA Conservation Reserve Program	4.7	10.3	13.9	13.4	3.6	2.0	2.8	4.0
Fallow	47.3	31.5	31.6	33.1	21.4	31.8	34.3	33.7
Grass Hay	20.2	18.4	16.8	15.7	17.1	12.3	14.1	13.8

Legume Hay	4.4	7.5	6.2	8.7	20.7	23.8	26.3	22.1
Hay/Pasture In Rotation	5.7	14.5	11.9	19.5	10.3	11.0	11.0	11.1
Irrigated	787.4	743.4	692.3	681.9	602.7	622.6	636.7	618.3
Low Residue	0.0	0.0	0.0	0.0	0.0	7.9	7.9	4.0
Other Crops	29.5	43.4	28.1	24.3	30.4	31.2	34.5	41.3
Rice	159.9	166.3	214.4	184.7	240.6	208.4	217.9	211.9
Row Crops	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Small Grains	80.9	54.6	40.4	34.9	56.2	39.6	56.9	45.1
Colorado	**3,258.1**	**3,584.1**	**2,803.8**	**3,128.1**	**3,001.0**	**3,375.2**	**3,519.0**	**3,146.7**
USDA Conservation Reserve Program	246.5	314.0	253.5	333.6	263.7	317.1	315.4	263.6
Fallow	1,525.5	1,643.2	1,235.6	1,280.1	1,190.8	1,562.1	1,557.5	1,276.7
Grass Hay	8.2	7.8	9.2	13.3	14.0	18.6	23.3	29.1
Legume Hay	16.0	18.3	13.2	17.4	18.7	25.1	32.8	25.0
Hay/Pasture In Rotation	7.8	8.0	7.3	8.2	13.8	19.5	13.2	10.1
Irrigated	917.9	858.1	819.7	858.7	853.5	793.0	827.3	805.5
Low Residue	0.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	207.4	226.9	168.3	179.7	240.2	295.0	360.7	310.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	88.3	72.4	106.7	180.2	159.9	132.3	132.0	188.3
Small Grains	240.1	433.6	190.2	256.6	246.2	212.6	256.7	237.6
Connecticut	**52.1**	**56.0**	**55.7**	**54.0**	**53.1**	**65.6**	**50.3**	**49.1**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Grass Hay	26.2	28.9	27.7	24.2	25.2	34.0	25.7	24.4
Legume Hay	4.5	5.5	9.4	9.1	8.1	12.8	8.5	9.2
Hay/Pasture In Rotation	2.5	1.5	2.2	3.0	2.2	0.4	0.3	0.6
Irrigated	0.0	0.0	0.2	0.2	1.0	0.6	0.7	0.5
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.8	0.4	0.0	1.3	0.4	0.2	0.2	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	17.1	19.3	16.3	15.9	16.2	17.5	13.7	12.9
Small Grains	0.0	0.4	0.0	0.0	0.0	0.0	1.4	1.4
Delaware	**119.5**	**118.6**	**133.5**	**114.1**	**113.2**	**125.3**	**124.8**	**120.8**
USDA Conservation Reserve Program	0.0	0.0	0.4	0.3	0.1	0.1	0.1	0.1
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	2.0	1.8	1.9	1.0	2.7	1.8	1.9	1.7
Legume Hay	1.0	0.4	0.5	1.0	0.7	0.8	0.8	0.8
Hay/Pasture In Rotation	2.9	1.7	1.1	3.3	0.7	1.7	1.0	0.8
Irrigated	6.3	8.9	17.0	22.4	26.1	28.5	32.2	34.0
Low Residue	0.3	0.9	0.4	0.4	0.0	0.0	0.0	0.0
Other Crops	1.3	1.4	0.4	1.0	1.1	1.3	1.4	2.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	104.9	96.9	108.8	81.7	78.4	85.0	80.3	70.0
Small Grains	0.9	6.6	3.0	3.0	3.3	6.1	7.2	11.0
Florida	**157.2**	**140.1**	**161.7**	**163.7**	**172.0**	**196.5**	**192.7**	**182.0**
USDA Conservation Reserve Program	3.1	3.7	3.1	4.0	3.7	3.2	2.8	3.3
Fallow	0.0	0.0	0.0	1.5	1.6	0.7	1.0	0.0
Grass Hay	11.9	14.9	21.9	30.5	39.1	44.9	37.8	39.8
Legume Hay	0.8	0.8	0.6	0.8	1.3	4.7	7.6	8.4
Hay/Pasture In Rotation	7.4	4.6	21.9	17.5	12.8	10.9	8.9	2.9
Irrigated	24.6	16.7	21.7	30.5	35.9	37.8	36.3	34.8
Low Residue	16.2	31.9	44.8	57.6	54.6	57.3	56.9	53.8
Other Crops	22.8	26.2	14.8	8.8	9.2	18.1	16.2	15.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	61.4	34.5	26.4	8.1	6.6	7.7	9.6	8.7
Small Grains	9.1	6.8	6.5	4.4	7.2	11.2	15.6	15.1
Georgia	**1,192.8**	**1,228.3**	**1,366.3**	**1,301.6**	**1,320.1**	**1,337.9**	**1,245.5**	**1,334.1**
USDA Conservation Reserve Program	11.1	16.1	17.0	19.3	22.7	24.2	21.5	23.6
Fallow	0.0	0.8	0.0	7.6	6.8	8.0	7.2	8.6
Grass Hay	39.5	43.5	77.7	106.8	109.3	131.2	125.7	138.0
Legume Hay	8.6	11.6	13.5	16.1	14.5	14.8	16.3	17.0
Hay/Pasture In Rotation	22.2	34.2	34.1	39.3	38.2	28.3	34.8	6.9
Irrigated	261.4	293.3	365.5	376.2	384.3	371.2	355.5	388.7
Low Residue	127.4	292.9	495.8	504.0	487.5	544.4	487.9	533.6

Other Crops	86.8	121.8	113.5	81.2	73.7	87.1	70.5	69.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	597.0	381.2	215.9	92.2	130.9	89.7	90.3	121.1
Small Grains	39.0	32.9	33.4	58.8	52.3	38.9	35.8	27.4
Idaho	**2,012.8**	**2,120.5**	**2,096.8**	**2,111.0**	**2,011.5**	**2,021.6**	**2,163.3**	**1,822.2**
USDA Conservation Reserve Program	104.6	138.7	101.4	135.4	80.5	58.8	67.7	67.7
Fallow	256.2	239.5	212.3	233.8	178.3	142.8	194.1	154.3
Grass Hay	14.6	21.1	17.2	18.9	27.1	22.5	20.4	22.1
Legume Hay	50.4	58.5	56.2	60.5	83.4	82.4	87.1	81.8
Hay/Pasture In Rotation	44.8	18.8	33.3	45.8	41.6	29.6	13.8	10.4
Irrigated	1,048.0	1,192.4	1,253.4	1,214.3	1,119.4	1,218.8	1,269.2	1,101.4
Low Residue	0.0	2.6	0.0	2.8	0.3	0.0	0.0	0.0
Other Crops	41.9	29.2	41.6	20.3	49.0	59.2	57.9	36.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.1	0.9	0.0	0.0	0.0	0.6	5.6	8.3
Small Grains	452.3	418.8	381.3	379.2	431.9	406.8	447.5	339.5
Illinois	**15,073.4**	**12,996.1**	**13,322.5**	**11,923.7**	**13,036.6**	**14,207.6**	**15,107.7**	**14,376.4**
USDA Conservation Reserve Program	126.3	163.5	128.5	123.2	131.7	118.4	107.0	94.3
Fallow	0.0	0.0	0.0	0.5	0.0	0.8	0.6	1.7
Grass Hay	35.6	33.4	41.9	66.6	77.4	87.9	85.9	80.5
Legume Hay	108.0	58.4	68.8	98.9	117.1	127.8	141.5	139.0
Hay/Pasture In Rotation	260.9	299.9	296.2	204.5	139.1	116.5	102.4	92.9
Irrigated	62.2	68.6	111.6	162.8	182.8	195.3	215.0	208.6
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	222.8	99.1	159.3	73.6	85.9	76.5	123.0	83.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	13,769.4	12,076.2	12,485.4	11,156.6	12,260.3	13,448.0	14,303.4	13,627.4
Small Grains	488.2	197.1	30.7	36.9	42.3	36.4	28.9	48.9
Indiana	**7,074.9**	**6,458.7**	**6,619.1**	**6,203.1**	**6,882.9**	**7,275.7**	**7,248.5**	**6,725.5**
USDA Conservation Reserve Program	72.9	79.9	45.9	34.8	25.5	21.9	20.5	19.3
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.2
Grass Hay	42.2	52.4	87.1	87.1	72.8	72.7	73.8	66.8
Legume Hay	87.3	64.3	99.8	116.8	135.4	151.8	152.0	137.8
Hay/Pasture In Rotation	201.7	193.8	126.2	119.0	97.5	82.2	73.3	64.2
Irrigated	60.1	68.5	80.3	105.3	102.0	105.4	109.8	106.5
Low Residue	6.8	6.3	1.0	2.4	1.9	2.1	1.9	2.8
Other Crops	358.2	156.0	78.5	45.9	26.0	33.7	15.6	11.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	6,061.5	5,750.7	6,056.3	5,647.5	6,399.7	6,782.2	6,779.1	6,285.1
Small Grains	184.3	86.9	44.1	44.2	21.9	23.7	21.5	30.7
Iowa	**16,281.6**	**15,206.0**	**14,455.9**	**16,420.1**	**14,889.0**	**15,843.7**	**20,782.4**	**17,310.6**
USDA Conservation Reserve Program	457.8	419.6	329.3	312.9	251.7	192.9	209.3	189.3
Fallow	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
Grass Hay	67.1	114.5	103.6	146.6	138.8	164.9	163.0	146.7
Legume Hay	183.7	185.9	199.0	214.9	245.2	247.1	292.4	284.4
Hay/Pasture In Rotation	858.6	550.5	436.5	404.1	312.3	304.8	298.3	278.1
Irrigated	66.7	94.7	111.9	127.4	117.5	125.3	148.1	140.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	645.7	381.7	227.8	176.8	201.2	154.6	226.4	160.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	13,821.6	13,383.3	13,035.5	15,022.2	13,613.0	14,648.1	19,433.8	16,103.6
Small Grains	180.2	75.8	12.3	13.9	9.2	5.8	11.0	7.2
Kansas	**11,887.9**	**12,701.7**	**11,332.0**	**14,396.0**	**13,811.3**	**16,462.6**	**14,795.9**	**14,260.4**
USDA Conservation Reserve Program	330.5	427.0	335.4	471.2	410.7	373.2	356.1	311.9
Fallow	2,903.7	3,444.4	3,047.1	3,465.6	2,457.1	3,004.3	3,133.6	2,875.9
Grass Hay	136.7	206.3	237.5	293.0	261.5	274.7	265.1	309.8
Legume Hay	137.3	187.2	203.7	287.0	272.1	290.5	274.4	277.2
Hay/Pasture In Rotation	306.5	196.1	171.1	238.2	179.0	165.1	137.1	137.3
Irrigated	1,631.5	1,593.6	1,509.9	1,649.3	1,683.2	1,859.2	1,662.6	1,771.4
Low Residue	0.0	0.0	0.0	5.7	9.9	0.0	2.6	0.4
Other Crops	787.7	530.3	699.8	999.2	841.5	1,309.2	1,136.5	1,020.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2,410.1	2,541.0	2,737.4	3,342.9	4,055.0	5,201.5	4,718.9	4,393.4

Small Grains	3,243.8	3,575.8	2,390.1	3,643.9	3,641.2	3,984.9	3,108.9	3,162.3
Kentucky	**2,146.7**	**2,228.8**	**2,396.7**	**2,210.9**	**2,425.2**	**2,666.8**	**2,866.4**	**2,811.7**
USDA Conservation Reserve Program	62.7	76.3	52.6	61.6	49.2	35.2	37.5	26.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	191.2	238.2	273.5	295.0	305.2	292.6	296.7	294.6
Legume Hay	232.3	263.5	338.9	374.4	408.4	390.0	392.3	403.9
Hay/Pasture In Rotation	236.2	221.8	253.1	151.4	168.9	184.7	191.5	101.8
Irrigated	3.2	8.8	34.0	29.7	19.3	18.0	20.7	20.3
Low Residue	57.4	82.9	57.1	32.0	28.2	19.8	19.6	28.3
Other Crops	79.4	63.7	42.6	32.8	47.8	87.4	91.9	76.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,231.5	1,216.9	1,302.6	1,189.7	1,338.6	1,527.7	1,719.6	1,748.9
Small Grains	52.9	56.7	42.4	44.2	59.6	111.6	96.6	111.5
Louisiana	**2,656.2**	**2,519.4**	**2,601.1**	**2,419.0**	**2,417.4**	**2,608.0**	**2,475.5**	**2,644.4**
USDA Conservation Reserve Program	2.6	3.5	7.6	16.6	24.9	23.3	24.9	22.7
Fallow	35.2	22.5	58.4	44.8	20.1	1.5	0.0	0.0
Grass Hay	41.1	39.2	36.4	66.1	86.6	83.0	82.9	86.1
Legume Hay	2.4	2.4	2.4	2.9	4.3	3.8	3.9	3.7
Hay/Pasture In Rotation	35.1	20.6	29.3	22.7	10.8	24.6	16.3	13.3
Irrigated	349.0	399.6	472.3	593.4	714.9	786.9	754.6	807.2
Low Residue	505.6	505.4	334.0	243.5	150.0	129.0	117.4	92.0
Other Crops	103.4	94.4	147.4	117.0	161.9	138.8	125.2	118.5
Rice	289.7	315.2	328.8	263.9	200.6	211.3	186.9	224.6
Row Crops	1,260.4	1,086.6	1,153.6	1,021.6	1,005.6	1,138.7	1,120.8	1,225.0
Small Grains	31.6	30.1	31.0	26.4	37.7	67.3	42.6	51.2
Maine	**153.1**	**149.4**	**144.0**	**158.6**	**156.3**	**141.9**	**121.0**	**124.9**
USDA Conservation Reserve Program	11.0	6.6	7.0	7.0	7.2	7.8	6.5	7.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	58.1	60.6	57.4	74.8	70.5	64.0	53.4	53.7
Legume Hay	28.1	34.4	32.1	34.0	30.3	32.5	28.9	30.4
Hay/Pasture In Rotation	15.2	6.5	10.2	5.8	9.3	0.5	2.7	3.0
Irrigated	1.8	0.4	0.7	1.4	1.5	1.4	1.1	1.3
Low Residue	15.9	18.6	23.3	14.3	16.5	10.3	12.1	7.8
Other Crops	9.5	8.0	1.8	5.5	6.5	12.6	6.4	7.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4.1	7.6	4.2	3.5	3.1	2.3	2.0	1.8
Small Grains	9.3	6.8	7.1	12.4	11.3	10.6	7.9	12.6
Maryland	**561.1**	**555.6**	**591.3**	**521.6**	**494.3**	**552.0**	**570.6**	**540.6**
USDA Conservation Reserve Program	0.8	2.5	2.5	4.6	1.3	1.2	1.3	1.0
Fallow	0.0	0.0	0.0	0.5	3.4	3.0	0.8	0.8
Grass Hay	27.7	36.8	48.0	51.5	39.2	48.3	47.5	44.8
Legume Hay	14.3	16.0	21.3	24.5	20.6	27.9	29.8	27.8
Hay/Pasture In Rotation	40.6	36.4	49.0	56.9	32.5	24.1	21.2	17.7
Irrigated	3.8	4.4	9.5	14.4	19.9	22.4	24.1	25.9
Low Residue	9.6	10.4	1.3	0.1	0.0	0.0	0.0	0.0
Other Crops	27.1	17.1	27.6	9.1	9.6	7.4	7.1	9.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	393.5	385.4	399.6	347.2	352.9	405.4	422.3	383.0
Small Grains	43.7	46.7	32.5	12.8	15.0	12.3	16.5	30.3
Massachusetts	**60.9**	**65.5**	**68.1**	**62.9**	**58.1**	**64.7**	**59.7**	**62.4**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8
Grass Hay	29.5	33.6	38.0	35.4	33.5	38.2	35.0	37.0
Legume Hay	12.6	14.3	16.9	17.1	15.3	18.3	17.5	17.6
Hay/Pasture In Rotation	3.1	5.5	4.3	0.4	4.1	1.3	1.9	2.4
Irrigated	0.9	0.9	0.9	0.9	1.3	1.2	1.1	1.3
Low Residue	0.5	0.9	2.6	2.8	0.0	0.7	0.7	0.8
Other Crops	0.2	0.3	0.0	0.0	0.1	1.1	0.4	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	14.1	10.1	5.4	6.3	3.8	3.0	2.1	2.2
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**2,956.2**	**2,807.1**	**2,956.2**	**2,667.0**	**2,887.5**	**2,886.7**	**2,937.0**	**2,810.0**
USDA Conservation Reserve Program	29.6	48.3	45.8	25.0	21.9	14.6	11.8	11.5

Fallow	1.3	5.9	10.2	9.4	3.8	7.2	4.6	8.7
Grass Hay	103.7	102.5	105.4	89.5	90.4	82.0	79.3	82.4
Legume Hay	285.3	287.5	320.7	317.1	332.0	283.0	287.6	289.5
Hay/Pasture In Rotation	273.1	246.3	180.4	167.9	177.6	120.7	103.2	80.9
Irrigated	109.4	124.8	148.5	144.2	168.7	184.5	184.9	180.3
Low Residue	8.9	14.6	4.3	1.6	5.1	1.9	5.1	3.6
Other Crops	161.7	125.9	112.1	83.6	55.7	79.0	78.3	78.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,840.5	1,763.1	2,000.9	1,801.0	1,979.1	2,068.5	2,154.0	2,038.6
Small Grains	142.7	88.1	27.9	27.9	53.2	45.5	28.2	35.6
Minnesota	**11,577.3**	**10,687.5**	**9,963.2**	**11,069.2**	**9,496.8**	**9,686.4**	**11,391.8**	**11,180.7**
USDA Conservation Reserve Program	270.5	289.5	228.6	250.6	208.4	142.1	141.5	105.3
Fallow	18.3	46.1	40.5	12.6	13.0	19.3	10.1	6.8
Grass Hay	112.6	152.5	127.5	204.2	178.1	142.5	172.3	157.1
Legume Hay	292.0	296.5	289.7	397.1	406.2	350.6	376.5	401.8
Hay/Pasture In Rotation	702.7	549.9	400.1	554.4	359.4	306.9	332.4	315.9
Irrigated	146.6	138.7	118.1	175.1	150.0	171.7	205.3	213.2
Low Residue	78.8	160.9	34.1	30.6	15.9	21.7	15.0	26.1
Other Crops	664.5	592.1	675.6	532.9	477.6	519.8	589.8	503.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	6,594.0	6,769.0	6,677.6	8,032.8	7,080.3	7,552.2	9,008.8	8,917.3
Small Grains	2,697.3	1,692.3	1,371.4	878.8	607.8	459.5	540.0	534.0
Mississippi	**2,713.2**	**2,634.2**	**2,733.5**	**2,527.9**	**2,613.6**	**2,752.0**	**2,884.0**	**2,825.7**
USDA Conservation Reserve Program	55.1	85.1	76.7	106.6	106.6	103.5	113.7	99.5
Fallow	0.0	0.0	3.5	19.1	1.5	14.5	14.9	18.1
Grass Hay	18.1	49.0	65.0	100.2	101.0	106.9	113.8	105.7
Legume Hay	2.5	6.3	5.4	8.9	11.7	10.6	11.2	10.1
Hay/Pasture In Rotation	31.4	31.8	32.9	13.3	17.7	9.9	14.8	23.3
Irrigated	528.6	605.5	852.4	894.2	1,082.3	1,121.1	1,127.7	1,187.4
Low Residue	604.2	606.5	546.5	390.7	181.1	170.2	181.5	137.0
Other Crops	222.4	126.7	71.7	61.3	25.8	39.2	45.1	44.4
Rice	188.9	202.2	112.7	147.1	108.2	76.3	108.3	79.3
Row Crops	1,013.4	891.5	958.2	775.5	954.1	1,069.4	1,125.8	1,089.4
Small Grains	48.6	29.5	8.4	11.0	23.6	30.5	27.3	31.4
Missouri	**7,818.3**	**6,806.0**	**7,000.8**	**6,704.9**	**7,652.3**	**8,526.0**	**8,333.5**	**8,422.2**
USDA Conservation Reserve Program	315.7	360.6	318.0	298.0	288.7	200.1	199.7	184.0
Fallow	0.0	1.4	7.8	0.9	15.7	6.1	4.3	6.1
Grass Hay	272.7	467.2	500.0	517.0	632.1	641.5	634.2	675.0
Legume Hay	284.5	347.6	427.2	455.7	536.4	550.9	525.0	534.0
Hay/Pasture In Rotation	347.3	325.5	206.6	215.4	237.6	259.9	224.8	148.6
Irrigated	411.3	505.0	633.7	636.4	665.8	732.9	797.0	749.3
Low Residue	115.9	105.9	78.6	64.1	49.4	29.0	35.6	22.5
Other Crops	341.7	255.5	216.9	81.7	128.6	220.9	212.0	204.3
Rice	62.8	56.7	79.5	175.1	179.3	125.9	128.2	96.5
Row Crops	5,064.2	3,979.5	4,343.3	4,120.5	4,796.0	5,652.6	5,432.3	5,649.5
Small Grains	602.1	401.0	189.3	140.2	122.7	106.3	140.5	152.5
Montana	**6,106.4**	**6,680.2**	**5,240.5**	**5,742.6**	**6,245.4**	**6,219.9**	**7,109.1**	**6,271.9**
USDA Conservation Reserve Program	364.2	494.8	455.0	549.9	528.7	351.6	279.2	213.9
Fallow	3,521.6	3,832.6	2,667.0	2,916.8	3,238.2	2,667.9	3,409.9	2,621.6
Grass Hay	91.7	107.3	87.6	154.5	201.0	209.0	256.1	218.9
Legume Hay	156.6	188.1	160.9	294.3	345.8	416.9	458.7	420.6
Hay/Pasture In Rotation	87.6	97.5	119.1	102.0	124.9	115.9	97.9	97.3
Irrigated	536.7	675.4	625.9	614.3	626.1	656.5	689.9	640.4
Low Residue	0.0	0.0	0.0	3.7	6.7	6.9	3.9	21.6
Other Crops	257.0	244.0	192.3	127.8	155.0	339.2	407.2	327.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.9	1.5	1.9	4.9	10.2	8.4	12.5	8.8
Small Grains	1,088.1	1,039.0	930.9	974.4	1,008.9	1,447.5	1,493.7	1,701.1
Nebraska	**8,809.9**	**9,699.5**	**8,913.8**	**11,242.3**	**10,375.5**	**11,676.9**	**11,555.0**	**11,115.9**
USDA Conservation Reserve Program	197.0	217.6	140.1	193.7	162.3	120.9	122.3	94.4
Fallow	617.6	682.0	697.1	739.5	648.1	696.3	810.4	682.0
Grass Hay	71.5	68.8	90.7	114.8	124.1	124.3	125.5	122.3
Legume Hay	172.2	212.3	193.5	233.7	193.4	200.4	200.0	215.3

Hay/Pasture In Rotation	219.0	272.4	187.2	277.2	182.5	147.9	125.3	108.4
Irrigated	3,351.2	3,979.0	3,855.9	4,808.9	4,560.1	5,144.9	4,750.9	4,905.9
Low Residue	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	437.1	366.7	299.2	295.0	345.8	310.0	260.2	304.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	3,140.2	3,400.8	3,271.7	4,260.6	3,946.3	4,742.5	4,958.0	4,530.0
Small Grains	603.7	499.9	178.5	318.9	213.0	189.7	202.4	153.7
Nevada	**158.8**	**168.5**	**172.2**	**214.6**	**176.9**	**131.5**	**154.4**	**194.9**
USDA Conservation Reserve Program	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.1	0.0	0.9	0.0
Grass Hay	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Legume Hay	0.1	0.4	0.3	0.7	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.1	1.7	0.0	0.0	0.1	0.1	0.1
Irrigated	151.8	156.7	161.8	211.5	174.8	127.8	149.0	190.5
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	6.7	10.9	8.5	2.3	2.0	3.5	4.3	3.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**41.8**	**40.3**	**42.3**	**49.6**	**42.2**	**47.0**	**41.3**	**42.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	28.5	26.4	28.3	32.2	28.2	30.9	27.1	27.9
Legume Hay	6.0	7.1	7.3	8.8	7.9	8.6	7.5	8.0
Hay/Pasture In Rotation	0.7	1.0	0.5	3.1	2.6	0.6	0.3	0.5
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	6.5	5.8	6.2	5.6	3.5	6.9	6.4	6.5
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**120.7**	**112.2**	**124.1**	**100.3**	**102.3**	**106.9**	**108.3**	**109.8**
USDA Conservation Reserve Program	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	1.6	2.2	1.6	2.6	1.3
Grass Hay	10.9	13.7	18.4	11.9	12.5	15.4	17.1	19.3
Legume Hay	6.7	11.5	13.6	10.4	10.5	12.5	15.5	15.3
Hay/Pasture In Rotation	18.3	6.6	13.4	21.8	7.7	5.8	4.9	3.0
Irrigated	0.4	0.3	1.7	3.5	5.6	5.3	5.5	5.6
Low Residue	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Other Crops	5.9	4.5	2.2	3.6	4.1	3.4	4.3	4.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	73.2	71.6	69.5	46.4	55.0	62.4	56.7	59.4
Small Grains	5.3	4.0	4.9	1.0	4.6	0.6	1.7	1.5
New Mexico	**595.9**	**560.1**	**484.9**	**500.9**	**500.0**	**589.7**	**518.4**	**458.8**
USDA Conservation Reserve Program	67.7	67.2	88.8	103.0	84.6	83.1	78.4	77.8
Fallow	5.2	12.3	6.6	10.9	21.0	49.1	41.1	33.4
Grass Hay	3.3	4.5	1.1	0.6	0.9	1.8	1.4	1.5
Legume Hay	1.4	3.4	0.8	0.4	0.7	11.6	9.9	19.3
Hay/Pasture In Rotation	0.8	0.6	4.2	0.3	0.4	5.4	1.4	0.6
Irrigated	246.1	214.4	216.7	229.5	213.3	201.9	195.5	190.0
Low Residue	4.1	3.9	0.0	1.6	1.0	1.0	0.7	3.2
Other Crops	38.3	24.1	40.3	12.1	20.4	45.2	42.0	27.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	61.6	48.2	23.5	34.3	19.4	19.3	12.8	16.6
Small Grains	167.5	181.4	102.9	108.1	138.2	171.2	135.2	88.6
New York	**1,744.5**	**1,658.9**	**1,900.7**	**1,734.9**	**1,814.5**	**1,981.2**	**1,793.0**	**1,825.1**
USDA Conservation Reserve Program	9.0	9.5	9.8	8.7	8.8	4.0	3.7	3.6
Fallow	6.4	0.9	0.0	2.1	9.1	11.9	9.7	11.2
Grass Hay	402.9	386.9	475.9	440.5	415.2	475.2	419.8	434.6
Legume Hay	374.0	400.6	528.9	500.3	481.6	535.6	467.2	482.4
Hay/Pasture In Rotation	413.2	363.6	362.8	334.0	294.4	248.6	218.4	214.2
Irrigated	1.6	0.5	0.7	0.3	0.4	0.0	0.0	0.0
Low Residue	3.2	3.2	1.4	0.0	0.0	0.0	0.0	0.0
Other Crops	93.4	64.4	67.9	34.2	73.0	68.5	87.0	74.7

Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	410.9	408.5	431.6	388.0	513.2	628.1	581.6	595.7
Small Grains	29.8	20.9	21.6	26.8	18.9	9.2	5.6	8.7
North Carolina	**1,511.1**	**1,586.7**	**1,586.4**	**1,447.7**	**1,478.3**	**1,539.4**	**1,495.1**	**1,497.3**
USDA Conservation Reserve Program	4.8	9.3	7.1	7.9	8.6	5.9	6.7	6.2
Fallow	2.9	4.7	0.2	12.6	11.0	12.8	12.2	14.6
Grass Hay	52.8	69.9	130.2	139.8	153.1	160.5	152.6	156.5
Legume Hay	18.8	10.5	15.5	16.6	15.1	16.8	18.7	18.1
Hay/Pasture In Rotation	33.9	44.0	39.4	50.4	30.8	25.9	27.1	15.9
Irrigated	81.5	77.8	83.4	69.6	41.1	39.9	38.9	37.4
Low Residue	160.6	318.9	381.1	392.2	274.0	271.4	315.2	298.2
Other Crops	77.7	126.6	174.4	125.3	145.4	207.1	172.9	192.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,024.6	832.9	697.1	601.1	729.0	702.1	648.6	642.6
Small Grains	53.5	92.0	57.8	32.1	70.1	97.0	102.2	115.0
North Dakota	**7,104.9**	**7,912.3**	**7,636.5**	**7,262.7**	**7,812.0**	**8,063.8**	**8,193.7**	**7,534.0**
USDA Conservation Reserve Program	304.0	399.5	451.5	449.1	342.0	195.7	171.5	124.1
Fallow	768.4	842.2	468.1	238.1	152.6	105.0	91.0	84.6
Grass Hay	73.7	105.1	93.6	115.8	132.6	121.8	124.5	100.8
Legume Hay	231.4	278.0	222.7	269.3	316.1	335.6	366.6	275.5
Hay/Pasture In Rotation	146.2	238.2	183.5	187.9	132.0	161.4	139.3	143.3
Irrigated	43.9	58.4	54.9	47.8	60.3	86.5	74.1	66.5
Low Residue	24.2	15.5	3.5	1.3	6.6	0.0	1.3	0.0
Other Crops	693.3	519.7	643.9	434.0	445.9	1,020.6	1,027.7	928.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	613.6	909.7	992.9	1,852.9	2,188.0	3,106.0	3,083.6	2,885.7
Small Grains	4,206.1	4,545.9	4,522.0	3,666.7	4,036.0	2,931.3	3,114.2	2,924.8
Ohio	**6,173.8**	**5,895.4**	**5,709.3**	**5,336.7**	**5,792.3**	**5,879.6**	**5,663.3**	**5,507.2**
USDA Conservation Reserve Program	51.1	70.0	49.2	33.7	38.8	26.1	19.1	17.1
Fallow	0.0	0.0	0.0	0.0	1.4	1.2	0.4	0.8
Grass Hay	104.4	124.9	163.7	241.9	165.0	176.1	186.7	183.0
Legume Hay	141.3	155.1	214.9	324.3	253.9	273.8	281.5	263.6
Hay/Pasture In Rotation	368.4	382.3	198.8	258.3	130.2	167.3	145.3	99.6
Irrigated	6.7	7.4	4.1	5.0	7.4	7.7	6.2	7.6
Low Residue	6.6	6.3	5.3	2.3	1.2	0.2	0.6	0.4
Other Crops	312.4	213.1	170.8	155.3	85.4	88.0	80.4	80.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4,758.7	4,553.0	4,870.9	4,276.3	5,077.1	5,117.1	4,925.9	4,822.1
Small Grains	424.2	383.3	31.7	39.4	32.0	22.2	17.4	33.0
Oklahoma	**3,882.5**	**3,526.1**	**3,227.8**	**3,367.0**	**3,878.6**	**4,439.0**	**4,082.5**	**3,793.1**
USDA Conservation Reserve Program	151.3	199.0	140.2	152.9	126.7	140.1	123.0	130.5
Fallow	42.3	27.2	22.0	22.7	26.8	74.3	73.6	101.4
Grass Hay	57.2	63.3	77.7	96.9	138.8	155.7	158.1	166.9
Legume Hay	34.1	46.1	60.7	94.1	101.1	129.7	129.5	128.5
Hay/Pasture In Rotation	59.1	48.3	96.7	77.7	113.4	44.1	49.6	42.2
Irrigated	298.3	247.4	248.6	266.2	300.7	310.9	271.2	282.7
Low Residue	132.4	142.9	87.3	21.7	48.0	33.8	39.8	33.2
Other Crops	71.6	40.8	67.1	24.8	31.2	76.7	55.0	65.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	263.2	173.9	134.9	119.9	162.6	198.5	132.9	137.2
Small Grains	2,773.0	2,537.3	2,292.5	2,490.2	2,829.3	3,275.0	3,049.8	2,704.5
Oregon	**1,199.9**	**1,125.4**	**1,137.4**	**1,272.2**	**1,354.7**	**1,282.5**	**1,184.4**	**856.3**
USDA Conservation Reserve Program	86.4	78.4	61.2	59.2	91.7	76.7	67.7	42.9
Fallow	508.7	477.7	414.3	519.3	523.3	559.1	493.0	277.8
Grass Hay	15.2	20.7	15.9	15.9	23.9	26.5	26.0	23.8
Legume Hay	16.9	18.5	17.2	20.8	26.4	25.7	26.1	22.9
Hay/Pasture In Rotation	13.0	10.7	22.5	18.2	13.5	7.8	3.9	8.8
Irrigated	339.7	346.1	372.1	391.0	367.5	353.4	354.7	351.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	18.4	9.0	59.7	9.1	6.3	18.5	6.2	1.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.3	3.1	1.5	0.3	0.5	0.4	0.5	0.4
Small Grains	199.3	161.2	173.0	238.5	301.6	214.3	206.4	127.3

Pennsylvania	**1,835.3**	**1,752.6**	**1,907.4**	**1,864.7**	**1,820.1**	**2,034.3**	**2,120.4**	**2,088.8**
USDA Conservation Reserve Program	12.8	13.8	8.1	6.6	4.0	4.4	2.3	1.8
Fallow	0.0	0.0	0.3	1.1	1.4	5.1	4.7	6.8
Grass Hay	271.1	270.0	311.9	367.5	307.4	370.5	416.9	421.9
Legume Hay	193.5	180.2	236.5	347.6	260.1	318.1	328.9	322.4
Hay/Pasture In Rotation	412.9	402.2	449.0	346.0	331.0	253.8	229.4	245.8
Irrigated	0.5	0.7	1.0	2.2	2.1	2.1	2.4	2.0
Low Residue	2.3	1.7	0.2	0.4	0.6	1.0	0.0	0.6
Other Crops	159.3	137.2	155.0	114.0	87.1	94.0	63.8	57.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	700.1	686.5	725.2	663.2	796.8	963.1	1,055.8	1,011.0
Small Grains	82.8	60.2	20.2	16.1	29.7	22.2	16.1	19.4
Rhode Island	**4.4**	**3.5**	**3.6**	**3.9**	**4.5**	**4.1**	**5.3**	**5.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	2.3	1.8	2.0	1.9	1.9	2.0	2.8	3.0
Legume Hay	0.5	0.6	0.6	0.3	0.3	0.4	0.7	0.7
Hay/Pasture In Rotation	0.0	0.0	0.0	0.8	0.6	0.1	0.1	0.0
Irrigated	0.7	0.6	0.5	0.5	0.3	0.3	0.4	0.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.8	0.5	0.4	0.5	0.8	1.0	1.1	1.1
Small Grains	0.0	0.0	0.0	0.0	0.6	0.2	0.2	0.2
South Carolina	**725.9**	**770.4**	**801.7**	**765.6**	**756.4**	**773.0**	**722.6**	**786.9**
USDA Conservation Reserve Program	7.4	11.3	14.3	15.7	13.7	13.3	12.3	13.2
Fallow	0.3	3.2	3.1	12.4	1.5	3.6	1.5	2.3
Grass Hay	28.9	45.1	59.6	83.1	101.6	111.5	101.1	102.6
Legume Hay	2.2	6.7	6.2	7.8	6.1	8.7	8.4	8.6
Hay/Pasture In Rotation	17.3	10.9	20.1	11.2	11.5	5.2	8.0	11.9
Irrigated	23.7	30.1	36.9	34.8	49.1	42.2	43.0	47.5
Low Residue	68.7	88.5	157.9	148.6	100.0	120.6	128.8	147.0
Other Crops	33.1	55.8	60.4	42.2	57.7	106.5	107.3	127.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	491.1	459.9	419.9	388.7	396.3	329.7	277.8	271.5
Small Grains	53.1	59.1	23.1	21.2	18.9	31.6	34.5	54.4
South Dakota	**7,610.6**	**7,847.9**	**6,826.3**	**8,776.6**	**8,840.2**	**10,038.4**	**11,272.0**	**10,092.2**
USDA Conservation Reserve Program	257.6	301.3	197.3	227.8	144.0	83.6	72.9	58.4
Fallow	737.3	759.9	369.7	358.3	299.9	311.3	299.8	246.1
Grass Hay	106.8	164.9	152.8	195.1	229.2	201.1	211.6	202.2
Legume Hay	320.7	411.0	299.2	445.3	527.7	528.8	572.6	541.1
Hay/Pasture In Rotation	321.9	372.1	314.0	454.8	321.1	224.7	208.9	235.3
Irrigated	200.0	205.7	186.7	226.3	184.0	219.6	257.0	229.9
Low Residue	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	773.8	542.2	536.5	285.4	414.2	397.5	447.8	347.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2,511.5	3,345.5	3,698.1	5,424.3	5,206.0	6,884.1	7,973.0	7,106.6
Small Grains	2,379.0	1,745.3	1,072.0	1,159.4	1,514.2	1,187.9	1,228.3	1,124.9
Tennessee	**1,737.2**	**1,817.8**	**1,784.2**	**1,726.0**	**1,736.4**	**2,120.5**	**2,241.0**	**1,972.6**
USDA Conservation Reserve Program	51.8	68.6	32.9	41.6	31.2	30.5	28.6	21.7
Fallow	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.2
Grass Hay	147.4	181.1	205.4	233.3	239.3	256.6	253.4	241.7
Legume Hay	95.1	131.2	178.7	204.8	194.8	203.8	200.3	192.5
Hay/Pasture In Rotation	108.6	118.6	96.9	50.1	59.6	94.7	73.1	25.4
Irrigated	1.7	3.4	11.1	21.3	37.4	48.2	54.7	50.7
Low Residue	229.5	353.0	286.6	304.1	185.7	217.4	219.2	158.5
Other Crops	55.4	43.1	60.6	29.2	59.5	74.6	78.7	89.3
Rice	0.0	0.0	0.0	0.5	1.4	0.0	0.0	0.0
Row Crops	1,014.3	895.2	895.9	803.2	885.7	1,132.4	1,243.8	1,132.6
Small Grains	33.4	23.6	16.0	37.8	41.7	61.9	88.9	59.9
Texas	**11,942.7**	**11,885.3**	**11,626.5**	**10,128.6**	**11,619.2**	**11,155.5**	**11,726.5**	**11,412.7**
USDA Conservation Reserve Program	499.5	649.7	522.3	589.0	505.1	487.9	519.3	485.9
Fallow	223.5	326.6	189.6	155.6	310.3	323.5	430.0	428.1

Grass Hay	170.7	119.5	164.3	213.5	376.1	465.5	492.2	569.9
Legume Hay	12.5	17.2	17.3	24.3	42.9	48.2	48.6	50.8
Hay/Pasture In Rotation	103.6	116.1	95.7	96.4	166.0	147.1	127.0	89.9
Irrigated	2,806.6	2,725.5	2,979.2	2,781.8	3,136.5	2,845.4	2,981.2	2,844.1
Low Residue	1,963.7	2,106.8	1,918.1	1,561.4	1,595.0	1,636.0	1,859.9	1,773.2
Other Crops	548.9	469.7	560.4	416.6	630.7	841.2	911.9	823.4
Rice	153.4	178.8	76.0	58.5	41.3	48.2	19.5	43.3
Row Crops	2,108.0	2,238.0	2,319.0	1,730.5	2,038.4	1,820.1	1,847.7	2,088.6
Small Grains	3,352.3	2,937.3	2,784.3	2,500.9	2,777.0	2,492.5	2,489.2	2,215.4
Utah	**527.5**	**544.6**	**526.5**	**534.9**	**542.9**	**555.4**	**588.3**	**570.2**
USDA Conservation Reserve Program	31.1	29.5	26.7	43.0	25.9	23.6	25.9	33.0
Fallow	92.8	130.5	69.5	47.4	62.8	49.2	50.9	81.4
Grass Hay	1.3	0.6	0.8	0.4	0.5	0.8	0.9	0.7
Legume Hay	9.5	11.8	9.3	7.4	6.2	11.2	9.7	10.2
Hay/Pasture In Rotation	8.8	3.4	7.2	4.9	7.5	1.3	0.1	2.5
Irrigated	340.4	340.8	375.9	392.9	378.5	384.2	403.3	386.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	21.5	12.4	18.5	14.8	27.8	56.2	37.6	35.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.9	0.0	1.5	3.6	4.8	13.8	16.0
Small Grains	22.1	14.7	18.6	22.8	30.0	24.3	46.0	4.6
Vermont	**265.2**	**252.0**	**269.2**	**281.9**	**273.6**	**292.8**	**275.4**	**286.5**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.3	2.9	2.0	1.1	0.0	0.7
Grass Hay	114.0	99.1	96.0	97.3	96.4	98.7	96.5	98.0
Legume Hay	78.5	87.7	85.5	83.4	87.7	92.3	79.0	82.7
Hay/Pasture In Rotation	30.2	26.1	40.0	51.3	33.3	38.0	33.1	33.9
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.2	1.0	0.8	1.1	1.4	2.8	2.2	0.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	41.0	38.0	46.5	44.6	52.8	59.8	64.5	70.2
Small Grains	0.3	0.0	0.0	1.3	0.0	0.0	0.0	0.0
Virginia	**884.6**	**960.4**	**1,066.6**	**921.6**	**978.9**	**1,044.4**	**1,038.9**	**1,078.4**
USDA Conservation Reserve Program	3.7	5.3	5.5	4.4	3.5	4.2	3.8	4.2
Fallow	0.0	0.0	0.0	0.0	1.3	1.9	2.3	2.4
Grass Hay	208.6	284.2	307.2	275.0	299.7	309.8	308.9	317.7
Legume Hay	84.0	95.1	148.0	154.7	167.5	168.9	174.1	180.2
Hay/Pasture In Rotation	85.5	73.2	92.8	60.7	51.4	39.7	38.0	26.3
Irrigated	29.2	31.6	36.2	26.8	23.8	21.5	23.0	22.7
Low Residue	38.3	68.4	69.9	42.5	30.4	32.9	42.7	40.4
Other Crops	61.6	49.6	55.0	42.2	41.7	39.1	43.9	52.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	325.6	284.1	314.0	248.3	300.9	370.5	346.3	375.9
Small Grains	48.1	69.0	38.2	67.2	58.7	55.9	55.9	56.0
Washington	**2,629.4**	**2,217.8**	**2,217.8**	**2,481.2**	**2,639.6**	**1,972.5**	**3,059.1**	**1,652.8**
USDA Conservation Reserve Program	135.1	149.2	137.2	203.1	241.8	171.4	216.4	131.9
Fallow	1,586.2	1,417.4	1,240.8	1,459.4	1,546.8	1,055.7	1,739.6	915.1
Grass Hay	29.2	33.4	22.2	26.9	25.0	27.3	29.2	26.9
Legume Hay	24.7	27.9	22.6	21.6	43.6	35.3	39.9	31.1
Hay/Pasture In Rotation	19.5	12.3	12.9	16.9	17.1	12.3	13.4	16.9
Irrigated	194.0	167.9	189.1	187.7	190.5	189.6	218.7	140.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	69.4	26.6	107.7	4.6	30.5	56.9	170.2	107.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.4	4.6	2.4	14.7	8.9	3.2	3.6	2.9
Small Grains	569.9	378.4	482.8	546.3	535.2	420.8	628.0	279.9
West Virginia	**242.1**	**223.4**	**270.8**	**275.1**	**200.4**	**213.6**	**205.9**	**194.0**
USDA Conservation Reserve Program	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	105.1	99.3	119.9	131.0	92.1	88.8	82.5	79.7
Legume Hay	64.7	65.0	93.2	98.4	68.0	74.4	77.6	69.3
Hay/Pasture In Rotation	12.9	7.5	11.6	9.1	5.3	10.9	11.6	6.3

Irrigated	0.0	0.0	0.6	0.4	0.0	0.0	0.0	0.0
Low Residue	1.7	2.0	1.4	0.4	0.0	0.0	0.0	0.0
Other Crops	2.8	3.5	0.5	0.2	0.9	3.1	1.9	1.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	54.9	43.6	41.1	35.6	34.2	36.5	32.4	37.4
Small Grains	0.0	2.6	2.4	0.0	0.0	0.0	0.0	0.0
Wisconsin	**4,455.8**	**4,372.6**	**4,079.0**	**4,288.9**	**4,430.8**	**4,298.2**	**4,906.2**	**4,735.8**
USDA Conservation Reserve Program	105.4	125.2	103.2	103.7	74.1	38.9	36.5	35.8
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	106.2	116.4	112.8	132.7	125.2	107.5	113.9	109.3
Legume Hay	476.7	408.0	377.6	429.2	465.0	390.5	415.0	423.2
Hay/Pasture In Rotation	1,270.0	1,169.6	943.9	913.1	791.4	620.3	688.7	691.4
Irrigated	25.9	27.3	25.5	45.4	51.1	55.0	62.5	60.8
Low Residue	9.1	6.0	5.5	3.7	0.0	0.0	0.0	0.0
Other Crops	516.9	463.4	308.0	339.7	254.6	208.5	250.7	179.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,827.9	1,975.0	2,168.5	2,296.7	2,641.4	2,833.7	3,303.2	3,205.2
Small Grains	117.6	81.7	34.0	24.7	28.0	44.0	35.8	30.3
Wyoming	**750.2**	**663.6**	**584.0**	**648.2**	**591.6**	**673.2**	**801.7**	**710.0**
USDA Conservation Reserve Program	29.6	32.9	25.2	31.5	24.4	25.4	29.4	22.1
Fallow	214.3	143.7	94.2	110.9	113.3	99.2	146.9	111.9
Grass Hay	49.9	47.0	44.0	66.8	61.6	66.2	82.4	76.3
Legume Hay	39.2	43.8	34.0	34.9	49.8	58.6	73.6	69.7
Hay/Pasture In Rotation	7.7	9.6	33.9	9.7	6.1	10.3	13.9	12.0
Irrigated	356.2	353.7	322.6	360.6	307.0	379.4	410.0	387.9
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	16.1	14.1	8.6	14.0	16.0	17.3	17.4	14.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.5	0.6	1.8	0.6	0.3	4.4	8.4	5.3
Small Grains	36.6	18.3	19.8	19.2	13.0	12.3	19.6	10.2

Note: Gg CO_2 eq. is Gigagrams carbon dioxide equivalent. Estimates are only for land area that is included in Tier 3 method. Other areas are only estimated in aggregate at national scale and so State-level data are not available. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method.

Appendix Table B-9 State-Level Estimates by Cropland Systems of Total Annual Indirect Nitrous Oxide Emissions From Volatilization, 1990, 1995, 2000, 2005, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*Gg CO2 eq.*[1]							
Alabama	**36.2**	**39.5**	**33.3**	**32.7**	**32.0**	**42.7**	**37.0**	**38.3**
USDA Conservation Reserve Program	1.1	1.3	1.4	2.2	1.7	1.8	1.7	1.8
Fallow	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.1
Grass Hay	1.8	2.8	2.9	5.5	5.2	6.9	5.6	7.2
Legume Hay	0.2	0.2	0.2	0.4	0.3	0.4	0.4	0.4
Hay/Pasture In Rotation	0.5	1.0	1.8	1.9	1.0	1.2	1.3	0.8
Irrigated	0.4	0.4	0.8	0.7	1.2	0.9	0.8	0.8
Low Residue	5.5	6.9	5.2	8.3	6.1	7.0	6.9	7.4
Other Crops	2.6	2.3	1.2	1.3	1.3	2.2	2.6	3.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	23.5	24.4	19.6	12.1	14.4	21.5	16.9	16.2
Small Grains	0.6	0.3	0.3	0.3	0.5	0.5	0.6	0.4
Arizona	**5.8**	**5.8**	**5.1**	**5.6**	**4.7**	**5.4**	**5.1**	**4.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.1
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Irrigated	5.6	5.5	4.8	4.8	4.3	4.6	4.3	4.2
Low Residue	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
Other Crops	0.2	0.3	0.3	0.2	0.4	0.6	0.6	0.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**144.0**	**148.2**	**138.6**	**134.1**	**140.3**	**138.5**	**149.2**	**155.0**
USDA Conservation Reserve Program	0.5	0.6	0.4	0.7	0.6	0.6	0.5	0.4
Fallow	0.2	0.0	0.3	0.5	1.6	1.4	2.2	1.4
Grass Hay	1.8	1.5	1.5	1.8	1.9	2.4	2.5	2.2
Legume Hay	0.1	0.1	0.1	0.3	0.2	0.3	0.3	0.3
Hay/Pasture In Rotation	0.1	0.5	0.3	0.2	0.0	0.1	0.0	0.0
Irrigated	62.9	73.4	88.5	91.9	96.5	94.8	105.0	110.9
Low Residue	6.4	7.4	4.3	1.7	1.4	1.5	1.0	0.6
Other Crops	1.6	2.1	1.2	0.7	1.4	1.1	1.0	2.4
Rice	29.6	28.8	18.4	17.1	21.4	21.0	18.4	19.1
Row Crops	39.4	31.8	22.2	17.2	13.9	14.6	17.1	16.1
Small Grains	1.5	2.0	1.5	2.0	1.4	0.8	1.0	1.5
California	**26.7**	**25.1**	**24.6**	**23.8**	**21.0**	**21.1**	**21.8**	**20.8**
USDA Conservation Reserve Program	0.1	0.2	0.3	0.4	0.1	0.1	0.1	0.1
Fallow	0.8	0.6	0.6	0.3	0.2	0.3	0.6	0.6
Grass Hay	0.5	0.5	0.4	0.4	0.4	0.3	0.4	0.4
Legume Hay	0.1	0.1	0.1	0.1	0.3	0.4	0.4	0.3
Hay/Pasture In Rotation	0.1	0.2	0.3	0.4	0.2	0.3	0.2	0.2
Irrigated	17.6	16.2	15.3	15.3	11.5	11.9	11.9	11.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1
Other Crops	0.6	1.0	0.7	0.5	0.7	0.7	0.8	0.9
Rice	5.0	4.9	5.9	5.3	6.4	6.1	6.2	6.2
Row Crops	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Small Grains	1.9	1.3	1.0	0.9	1.3	0.7	1.1	0.9
Colorado	**69.1**	**83.1**	**66.3**	**67.7**	**68.1**	**71.3**	**75.0**	**67.1**
USDA Conservation Reserve Program	9.0	13.6	7.6	10.1	8.8	7.8	8.7	8.1
Fallow	24.1	30.3	23.7	22.8	21.6	29.3	28.3	21.8
Grass Hay	0.2	0.1	0.2	0.3	0.3	0.5	0.6	0.7

Legume Hay	0.3	0.3	0.2	0.4	0.3	0.4	0.4	0.3
Hay/Pasture In Rotation	0.1	0.1	0.1	0.2	0.3	0.4	0.3	0.2
Irrigated	23.5	21.8	22.9	20.6	21.2	18.8	19.5	19.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	5.1	5.2	4.0	4.1	5.5	6.1	7.9	7.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.2	1.8	3.1	4.2	4.2	3.4	3.5	4.9
Small Grains	4.6	9.9	4.5	5.2	6.0	4.6	5.7	5.0
Connecticut	**1.4**	**1.4**	**1.5**	**1.3**	**1.4**	**1.7**	**1.2**	**1.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.8	0.9	0.9	0.7	0.7	1.0	0.7	0.7
Legume Hay	0.1	0.1	0.2	0.2	0.1	0.2	0.1	0.2
Hay/Pasture In Rotation	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	**5.4**	**5.1**	**5.3**	**4.9**	**5.3**	**4.9**	**5.0**	**5.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.0
Irrigated	0.3	0.5	0.7	1.0	1.2	1.0	1.2	1.4
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4.9	4.3	4.4	3.6	3.8	3.5	3.5	3.3
Small Grains	0.0	0.2	0.1	0.1	0.1	0.2	0.2	0.3
Florida	**5.3**	**4.3**	**5.0**	**4.1**	**5.1**	**6.1**	**5.5**	**4.7**
USDA Conservation Reserve Program	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.5	0.6	0.8	1.1	1.5	1.7	1.5	1.6
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Hay/Pasture In Rotation	0.2	0.2	0.8	0.5	0.3	0.4	0.2	0.1
Irrigated	0.7	0.4	0.6	0.7	1.0	1.0	1.0	0.9
Low Residue	0.3	0.9	1.2	1.0	1.3	1.5	1.3	0.8
Other Crops	0.6	0.7	0.5	0.3	0.3	0.7	0.5	0.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.6	1.2	0.8	0.3	0.4	0.3	0.4	0.4
Small Grains	0.2	0.2	0.2	0.1	0.2	0.3	0.4	0.3
Georgia	**50.5**	**40.3**	**45.7**	**38.4**	**42.4**	**46.5**	**42.1**	**43.6**
USDA Conservation Reserve Program	0.4	0.5	0.6	0.8	0.8	0.9	0.8	0.8
Fallow	0.0	0.0	0.0	0.1	0.1	0.4	0.1	0.1
Grass Hay	1.8	2.2	3.6	5.0	5.4	6.2	5.9	6.8
Legume Hay	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Hay/Pasture In Rotation	0.9	1.2	1.2	1.6	1.4	1.0	1.3	0.2
Irrigated	9.6	7.8	11.8	9.5	11.4	11.5	11.1	12.0
Low Residue	3.7	7.7	14.6	12.8	13.4	15.9	13.1	15.2
Other Crops	2.8	3.6	3.8	2.6	2.4	3.4	3.1	2.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	29.7	15.9	8.8	4.0	5.4	5.3	5.2	4.9
Small Grains	1.5	1.1	1.1	1.8	1.7	1.6	1.2	1.0
Idaho	**37.7**	**38.3**	**39.2**	**35.3**	**32.8**	**33.7**	**41.2**	**33.8**
USDA Conservation Reserve Program	2.3	3.0	1.6	2.1	1.2	1.0	1.3	1.2
Fallow	3.9	3.9	3.2	3.2	2.6	1.8	3.1	2.5

Grass Hay	0.2	0.3	0.3	0.3	0.3	0.4	0.3	0.4
Legume Hay	0.6	0.7	0.7	0.6	0.8	0.9	0.9	0.9
Hay/Pasture In Rotation	0.7	0.3	0.5	0.7	0.6	0.4	0.2	0.2
Irrigated	20.8	21.5	24.9	20.7	19.3	21.7	26.4	22.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.8	0.5	0.7	0.4	0.7	0.7	0.9	0.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Small Grains	8.5	7.9	7.4	7.3	7.4	6.7	7.9	5.6
Illinois	**481.6**	**442.1**	**563.7**	**449.8**	**515.4**	**533.3**	**606.1**	**588.8**
USDA Conservation Reserve Program	4.8	5.3	4.7	4.2	4.4	4.1	3.6	3.3
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Grass Hay	0.7	0.6	0.8	1.4	1.2	1.6	1.6	1.5
Legume Hay	1.3	0.6	0.7	1.3	1.1	1.3	1.5	1.3
Hay/Pasture In Rotation	5.7	7.9	7.7	5.7	3.9	2.7	2.9	1.8
Irrigated	2.5	2.9	4.9	7.1	6.5	7.5	8.6	9.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	5.5	2.3	5.8	1.9	3.1	2.3	4.7	3.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	448.9	417.4	538.3	427.3	494.1	513.1	582.5	567.9
Small Grains	12.2	5.0	0.7	0.8	1.1	0.7	0.7	0.9
Indiana	**247.9**	**235.4**	**292.9**	**294.3**	**324.3**	**323.8**	**310.5**	**304.9**
USDA Conservation Reserve Program	2.6	2.7	1.6	1.2	0.9	0.8	0.7	0.7
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	1.0	1.2	2.2	2.2	1.5	1.8	1.9	1.6
Legume Hay	1.2	0.9	1.2	1.6	1.5	1.9	1.7	1.6
Hay/Pasture In Rotation	5.6	5.5	3.1	4.1	4.0	3.1	2.3	1.9
Irrigated	2.4	2.7	3.8	5.3	5.3	5.0	4.8	4.6
Low Residue	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	11.4	4.9	3.1	1.4	1.0	1.1	0.5	0.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	218.9	215.1	276.8	277.4	309.6	309.7	298.2	293.2
Small Grains	4.8	2.3	1.1	1.1	0.5	0.5	0.4	0.8
Iowa	**517.8**	**472.8**	**596.0**	**629.4**	**592.7**	**553.8**	**705.4**	**619.3**
USDA Conservation Reserve Program	17.4	14.5	13.3	11.1	9.3	6.6	7.6	7.0
Fallow	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Grass Hay	1.1	2.1	2.1	2.8	2.6	3.1	3.0	2.6
Legume Hay	1.9	1.9	2.3	2.4	2.2	2.8	3.1	2.6
Hay/Pasture In Rotation	18.2	11.9	13.3	10.8	8.3	7.0	8.2	6.6
Irrigated	2.8	3.0	4.3	4.8	4.2	4.2	4.7	4.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	17.0	8.4	7.5	4.1	6.8	4.8	6.7	4.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	455.0	429.6	553.2	593.0	558.9	525.3	671.9	592.0
Small Grains	4.4	1.5	0.3	0.3	0.2	0.1	0.2	0.1
Kansas	**258.6**	**298.8**	**300.0**	**359.4**	**359.7**	**393.3**	**352.8**	**376.5**
USDA Conservation Reserve Program	14.2	15.6	11.4	16.5	12.7	10.4	10.6	9.7
Fallow	40.8	57.2	59.0	61.0	37.7	47.8	51.5	45.6
Grass Hay	3.0	4.3	5.0	6.4	5.5	5.9	5.6	6.5
Legume Hay	2.2	2.6	2.7	3.5	3.0	4.2	3.4	3.5
Hay/Pasture In Rotation	6.5	4.2	3.1	5.4	4.8	3.5	3.6	3.3
Irrigated	39.2	45.7	51.3	51.5	54.3	53.4	45.3	56.6
Low Residue	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.0
Other Crops	16.2	10.5	16.6	22.2	19.5	26.7	23.0	23.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	67.9	78.2	93.7	114.8	142.5	159.1	148.6	157.7
Small Grains	68.8	80.5	57.0	78.0	79.1	82.6	61.2	69.8
Kentucky	**68.7**	**73.4**	**78.8**	**74.2**	**83.6**	**99.3**	**98.3**	**114.5**

USDA Conservation Reserve Program	2.3	2.8	2.0	2.3	1.8	1.4	1.2	1.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	6.3	7.5	9.4	10.3	10.0	10.9	10.1	10.6
Legume Hay	3.4	3.8	5.0	5.6	5.6	5.3	5.2	5.5
Hay/Pasture In Rotation	6.1	6.0	5.8	4.6	6.3	8.0	7.4	3.9
Irrigated	0.1	0.1	0.9	0.7	0.8	0.5	0.7	0.8
Low Residue	0.7	1.2	1.0	0.5	0.4	0.4	0.4	0.5
Other Crops	2.4	1.8	1.4	0.9	1.6	3.0	3.0	2.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	45.9	48.6	52.2	48.1	55.8	67.1	68.3	87.5
Small Grains	1.6	1.7	1.2	1.2	1.4	2.7	2.0	2.6
Louisiana	**90.8**	**83.2**	**85.7**	**82.3**	**88.0**	**100.7**	**100.8**	**104.8**
USDA Conservation Reserve Program	0.1	0.1	0.3	0.6	0.8	0.7	0.8	0.7
Fallow	0.5	0.7	2.5	1.3	0.9	0.1	0.0	0.0
Grass Hay	1.2	1.2	1.2	1.9	2.2	2.3	2.3	2.2
Legume Hay	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Hay/Pasture In Rotation	1.0	0.7	0.6	0.8	0.4	1.1	0.7	0.6
Irrigated	11.9	14.0	16.9	17.7	24.9	28.9	31.1	30.2
Low Residue	9.4	10.8	6.6	6.1	3.4	3.1	2.1	2.4
Other Crops	3.3	2.8	5.1	3.7	6.0	4.7	5.0	4.4
Rice	8.9	10.0	9.4	7.8	5.5	6.0	5.1	5.6
Row Crops	53.6	42.0	42.2	41.8	42.8	52.3	51.8	57.3
Small Grains	0.8	0.7	0.9	0.6	1.0	1.5	1.8	1.4
Maine	**3.5**	**2.9**	**2.9**	**3.8**	**3.8**	**3.2**	**2.3**	**2.7**
USDA Conservation Reserve Program	0.6	0.3	0.3	0.3	0.3	0.4	0.3	0.3
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	1.4	1.4	1.4	2.0	2.1	1.6	1.2	1.3
Legume Hay	0.4	0.4	0.5	0.6	0.5	0.5	0.4	0.4
Hay/Pasture In Rotation	0.3	0.1	0.2	0.1	0.2	0.0	0.0	0.1
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.2	0.2	0.3	0.2	0.3	0.2	0.1	0.1
Other Crops	0.2	0.1	0.0	0.1	0.2	0.3	0.1	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Small Grains	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.2
Maryland	**20.2**	**20.1**	**22.5**	**21.4**	**20.4**	**24.3**	**25.1**	**23.2**
USDA Conservation Reserve Program	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.0
Fallow	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1
Grass Hay	1.2	1.5	1.9	2.0	1.3	1.7	1.6	1.5
Legume Hay	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.4
Hay/Pasture In Rotation	1.2	1.2	1.3	1.7	1.1	0.9	0.6	0.6
Irrigated	0.2	0.2	0.4	0.6	1.0	0.9	1.1	1.1
Low Residue	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.9	0.5	0.9	0.3	0.3	0.2	0.2	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	14.8	14.5	16.5	15.8	15.8	19.6	20.6	18.2
Small Grains	1.5	1.6	1.0	0.4	0.4	0.3	0.4	0.9
Massachusetts	**1.6**	**1.7**	**1.6**	**1.7**	**1.5**	**1.6**	**1.4**	**1.7**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.9	1.1	1.1	1.1	1.0	1.1	1.0	1.2
Legume Hay	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Hay/Pasture In Rotation	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.4	0.3	0.1	0.2	0.1	0.1	0.1	0.1
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Michigan	**88.5**	**91.6**	**101.8**	**97.4**	**110.6**	**111.7**	**113.2**	**124.2**
USDA Conservation Reserve Program	1.2	1.7	1.7	0.9	0.8	0.5	0.4	0.4
Fallow	0.0	0.2	0.2	0.2	0.1	0.2	0.1	0.1
Grass Hay	3.2	2.9	3.2	2.7	2.6	2.3	2.3	2.4
Legume Hay	5.1	4.9	5.3	5.5	5.1	4.2	4.2	4.5
Hay/Pasture In Rotation	6.7	6.4	4.0	4.9	5.5	3.8	2.9	2.5
Irrigated	3.7	4.6	5.5	6.2	7.1	7.4	7.5	8.3
Low Residue	0.1	0.4	0.1	0.0	0.1	0.0	0.1	0.1
Other Crops	4.6	3.6	3.6	2.1	1.8	2.3	2.3	2.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	60.2	64.4	77.4	74.2	86.1	90.0	92.5	102.4
Small Grains	3.6	2.5	0.8	0.7	1.5	1.0	0.9	0.8
Minnesota	**314.6**	**279.4**	**309.9**	**318.8**	**365.3**	**315.6**	**346.2**	**367.9**
USDA Conservation Reserve Program	10.2	9.2	7.6	7.8	6.8	4.2	4.4	3.5
Fallow	0.4	0.7	1.1	0.1	0.3	0.4	0.3	0.3
Grass Hay	2.3	3.2	2.7	3.7	4.2	3.1	3.7	3.8
Legume Hay	3.9	3.8	3.9	4.6	5.3	4.7	4.6	5.1
Hay/Pasture In Rotation	13.8	11.4	7.6	11.8	9.4	7.6	7.5	6.5
Irrigated	4.0	3.7	4.1	5.1	6.5	6.0	6.3	8.0
Low Residue	1.2	1.7	0.3	0.2	0.2	0.2	0.2	0.4
Other Crops	15.4	11.5	15.4	11.7	13.7	12.5	14.1	14.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	205.9	203.5	239.8	258.5	303.5	268.2	294.6	313.8
Small Grains	57.5	30.5	27.3	15.3	15.4	8.6	10.5	11.6
Mississippi	**89.4**	**89.1**	**87.3**	**87.3**	**94.6**	**106.3**	**116.8**	**101.3**
USDA Conservation Reserve Program	1.9	2.8	2.5	3.6	3.4	3.1	3.5	3.1
Fallow	0.0	0.0	0.2	0.4	0.1	0.3	0.8	0.5
Grass Hay	0.6	1.6	1.8	3.2	3.0	3.4	3.6	3.2
Legume Hay	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Hay/Pasture In Rotation	0.9	1.1	1.0	0.5	0.9	0.3	0.9	1.2
Irrigated	17.0	20.4	27.8	30.0	41.6	44.8	47.1	44.3
Low Residue	14.0	13.9	10.1	8.7	3.4	4.3	4.7	3.5
Other Crops	6.2	4.4	2.7	2.4	0.9	1.4	1.3	1.2
Rice	5.6	5.4	2.2	3.0	2.0	1.6	1.7	1.4
Row Crops	42.0	38.5	38.6	35.1	38.3	46.3	52.2	41.9
Small Grains	1.2	0.9	0.2	0.3	0.8	0.7	0.7	1.0
Missouri	**248.7**	**231.4**	**256.0**	**237.8**	**293.7**	**284.5**	**336.4**	**299.8**
USDA Conservation Reserve Program	11.2	11.9	12.0	10.0	9.7	6.3	7.1	6.4
Fallow	0.0	0.0	0.4	0.1	0.3	0.3	0.1	0.1
Grass Hay	7.1	11.1	13.8	14.7	16.9	16.7	17.2	18.7
Legume Hay	4.4	5.1	6.6	7.3	7.2	8.4	7.6	7.6
Hay/Pasture In Rotation	9.1	8.7	6.1	7.1	8.3	10.3	9.8	5.8
Irrigated	12.9	16.6	21.9	22.7	29.3	27.0	30.4	31.9
Low Residue	2.6	2.5	1.6	1.4	1.3	0.8	0.9	0.9
Other Crops	10.0	7.0	7.0	2.1	4.9	8.0	8.5	7.3
Rice	1.5	1.8	2.0	5.0	4.3	3.5	2.9	2.8
Row Crops	174.5	156.2	179.7	163.5	208.5	200.6	249.0	214.7
Small Grains	15.3	10.4	5.1	3.8	3.0	2.7	2.8	3.7
Montana	**103.9**	**131.4**	**104.0**	**108.5**	**108.3**	**116.7**	**123.7**	**111.5**
USDA Conservation Reserve Program	12.5	17.0	14.7	18.4	18.2	11.4	7.8	5.2
Fallow	51.3	66.4	47.9	48.1	47.4	44.2	56.3	42.9
Grass Hay	1.6	1.9	1.4	2.4	3.3	3.8	4.2	3.6
Legume Hay	2.5	3.1	2.4	4.6	4.8	6.3	6.8	6.2
Hay/Pasture In Rotation	1.3	2.1	2.1	1.5	1.6	1.7	1.3	1.5
Irrigated	10.5	13.9	12.8	12.9	12.2	13.3	13.4	12.5
Low Residue	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.3
Other Crops	5.7	6.8	3.8	2.5	2.7	6.7	7.2	6.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.2
Small Grains	18.5	20.2	18.9	18.0	17.8	28.9	26.4	33.1
Nebraska	**258.7**	**267.7**	**302.6**	**389.4**	**394.4**	**397.6**	**426.3**	**400.4**
USDA Conservation Reserve Program	7.4	6.5	4.5	6.4	5.3	3.4	3.7	2.9
Fallow	9.9	10.8	11.6	12.7	10.4	11.4	14.7	9.9
Grass Hay	1.9	1.7	1.9	2.8	2.7	2.8	3.0	2.8
Legume Hay	2.8	3.1	2.9	3.3	2.4	2.8	2.7	2.8
Hay/Pasture In Rotation	4.7	6.3	4.2	6.5	5.8	4.1	4.2	2.5
Irrigated	107.7	120.0	147.3	189.8	189.3	193.2	196.6	191.9
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	11.2	7.4	7.3	7.5	8.8	7.9	6.8	7.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	100.2	101.6	119.2	153.0	165.0	168.0	190.3	176.9
Small Grains	13.0	10.4	3.8	7.4	4.7	4.1	4.4	3.0
Nevada	**2.9**	**2.9**	**2.8**	**3.4**	**2.9**	**2.2**	**2.8**	**4.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	2.7	2.6	2.6	3.3	2.9	2.2	2.7	4.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.2	0.2	0.2	0.0	0.0	0.1	0.1	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**0.9**	**0.8**	**0.8**	**1.0**	**0.9**	**1.0**	**0.9**	**0.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.7	0.6	0.6	0.7	0.7	0.7	0.6	0.7
Legume Hay	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Hay/Pasture In Rotation	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**4.5**	**4.1**	**4.0**	**3.9**	**4.4**	**4.4**	**4.6**	**4.8**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Grass Hay	0.4	0.5	0.6	0.4	0.4	0.4	0.5	0.5
Legume Hay	0.1	0.2	0.3	0.2	0.2	0.2	0.3	0.3
Hay/Pasture In Rotation	0.5	0.2	0.3	0.9	0.3	0.2	0.2	0.1
Irrigated	0.0	0.0	0.0	0.2	0.3	0.2	0.4	0.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	3.0	2.9	2.6	2.1	2.7	3.2	3.1	3.4
Small Grains	0.2	0.1	0.1	0.0	0.2	0.0	0.0	0.0
New Mexico	**14.9**	**14.5**	**12.5**	**14.5**	**12.8**	**15.9**	**13.5**	**11.4**
USDA Conservation Reserve Program	1.8	2.0	3.0	4.1	2.8	2.6	2.8	3.1
Fallow	0.1	0.2	0.1	0.2	0.3	1.0	0.9	0.6
Grass Hay	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.3
Hay/Pasture In Rotation	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Irrigated	6.5	5.5	5.2	5.8	5.1	4.8	4.8	4.5
Low Residue	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1
Other Crops	0.9	0.6	1.0	0.3	0.5	1.2	1.1	0.6

Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.6	1.2	0.6	0.8	0.5	0.5	0.3	0.3
Small Grains	3.8	4.7	2.5	3.1	3.5	5.3	3.5	1.8
New York	**36.0**	**35.6**	**38.4**	**38.0**	**43.6**	**45.5**	**40.3**	**43.5**
USDA Conservation Reserve Program	0.3	0.3	0.4	0.3	0.4	0.1	0.1	0.1
Fallow	0.1	0.0	0.0	0.0	0.2	0.3	0.2	0.3
Grass Hay	10.4	10.1	11.4	10.8	10.2	11.8	10.6	11.5
Legume Hay	6.1	6.7	8.2	8.3	7.8	8.0	6.7	7.5
Hay/Pasture In Rotation	7.9	7.5	6.4	7.4	6.5	5.5	4.6	4.4
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	2.2	1.5	1.7	0.9	1.8	1.7	1.8	1.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	8.3	9.1	9.9	9.6	16.3	17.9	16.2	17.5
Small Grains	0.6	0.4	0.5	0.5	0.5	0.2	0.1	0.2
North Carolina	**63.9**	**59.8**	**63.8**	**67.2**	**63.9**	**64.9**	**67.3**	**65.3**
USDA Conservation Reserve Program	0.2	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Fallow	0.1	0.2	0.0	0.3	0.4	0.4	0.2	0.3
Grass Hay	2.5	3.2	5.9	5.9	6.8	6.8	6.7	6.8
Legume Hay	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Hay/Pasture In Rotation	1.2	1.6	1.6	2.1	1.2	1.2	1.2	0.6
Irrigated	3.1	2.6	2.9	2.8	1.4	1.5	1.3	1.5
Low Residue	4.1	8.6	11.5	13.9	7.7	8.6	10.5	10.2
Other Crops	2.9	4.4	6.5	5.4	4.9	7.1	8.0	6.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	47.1	35.1	32.6	34.9	38.9	35.4	35.3	35.2
Small Grains	2.1	3.6	2.2	1.2	2.1	3.3	3.5	3.5
North Dakota	**145.5**	**157.3**	**171.6**	**190.6**	**207.1**	**193.3**	**218.4**	**221.4**
USDA Conservation Reserve Program	9.9	9.6	10.3	10.1	7.7	4.1	3.7	2.6
Fallow	12.3	13.2	7.6	3.8	2.2	1.7	1.1	1.3
Grass Hay	1.4	2.1	1.7	2.0	2.4	2.1	2.2	1.7
Legume Hay	4.5	4.3	3.6	4.2	4.4	4.7	5.0	4.4
Hay/Pasture In Rotation	2.8	4.5	3.5	4.2	2.7	3.5	2.9	2.8
Irrigated	0.8	1.1	1.2	1.5	2.1	1.9	1.9	2.0
Low Residue	0.3	0.2	0.0	0.0	0.1	0.0	0.0	0.0
Other Crops	13.9	10.1	14.3	11.4	13.5	25.0	28.6	28.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	13.3	21.7	31.5	70.3	89.3	86.3	107.5	110.3
Small Grains	86.2	90.5	97.8	83.1	82.8	64.0	65.4	67.5
Ohio	**184.4**	**197.9**	**201.0**	**193.0**	**244.7**	**245.3**	**234.3**	**232.5**
USDA Conservation Reserve Program	1.8	2.2	1.7	1.1	1.3	0.9	0.6	0.6
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	3.3	3.9	5.1	6.9	5.1	5.8	5.8	6.1
Legume Hay	2.0	2.3	3.0	5.7	3.4	3.8	3.8	3.7
Hay/Pasture In Rotation	8.2	10.2	4.1	6.7	3.9	4.8	4.5	2.8
Irrigated	0.2	0.3	0.2	0.1	0.4	0.3	0.4	0.2
Low Residue	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Other Crops	7.0	5.7	5.0	4.1	3.1	2.5	2.6	2.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	153.0	163.9	181.1	167.5	226.7	226.8	216.0	215.9
Small Grains	8.8	9.3	0.8	0.9	0.9	0.4	0.4	0.6
Oklahoma	**99.1**	**96.3**	**83.4**	**88.3**	**89.7**	**106.1**	**90.2**	**90.4**
USDA Conservation Reserve Program	6.1	8.4	5.2	5.6	4.2	4.3	3.9	4.3
Fallow	0.6	0.5	0.4	0.6	0.4	1.4	1.3	1.9
Grass Hay	1.6	1.9	2.3	3.0	4.3	4.7	5.1	5.2
Legume Hay	0.7	0.8	1.0	1.9	1.9	2.5	2.5	2.3
Hay/Pasture In Rotation	1.4	1.1	1.6	2.0	2.5	0.8	1.0	0.9
Irrigated	7.0	6.1	6.5	7.4	7.3	8.2	7.3	8.1

Low Residue	2.8	3.1	1.9	0.5	1.1	0.8	1.0	0.7
Other Crops	1.9	1.1	1.4	0.6	0.8	1.8	1.2	1.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	8.2	6.7	5.4	4.6	5.5	6.2	4.8	4.7
Small Grains	68.8	66.5	57.7	61.9	61.8	75.5	62.0	60.4
Oregon	**23.1**	**20.8**	**19.3**	**20.0**	**19.3**	**23.6**	**21.4**	**16.0**
USDA Conservation Reserve Program	1.6	1.9	1.0	0.8	1.2	1.1	1.0	0.8
Fallow	9.3	7.8	5.9	6.2	4.7	9.0	7.1	3.6
Grass Hay	0.4	0.6	0.5	0.5	0.7	0.8	0.8	0.7
Legume Hay	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Hay/Pasture In Rotation	0.3	0.2	0.3	0.3	0.2	0.1	0.1	0.1
Irrigated	7.0	6.9	7.0	7.2	6.3	7.0	7.2	7.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.3	0.1	1.2	0.2	0.1	0.3	0.1	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	3.7	2.9	3.2	4.5	5.6	4.8	4.8	3.3
Pennsylvania	**47.7**	**46.7**	**54.4**	**53.7**	**58.1**	**64.6**	**66.8**	**70.9**
USDA Conservation Reserve Program	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.1
Fallow	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Grass Hay	9.1	8.9	10.7	11.1	10.7	12.3	14.1	14.4
Legume Hay	3.7	3.2	4.3	6.7	4.7	5.8	6.1	5.9
Hay/Pasture In Rotation	9.9	10.0	10.7	9.2	9.1	6.7	5.9	6.6
Irrigated	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Low Residue	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	4.4	3.3	4.2	3.2	2.6	2.9	1.7	1.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	17.9	19.1	23.5	22.7	29.9	36.0	38.3	41.2
Small Grains	2.0	1.6	0.6	0.5	0.9	0.6	0.5	0.6
Rhode Island	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	**35.1**	**34.5**	**36.9**	**36.9**	**39.2**	**31.2**	**30.2**	**32.3**
USDA Conservation Reserve Program	0.3	0.4	0.6	0.7	0.5	0.5	0.5	0.5
Fallow	0.0	0.1	0.1	0.3	0.0	0.1	0.1	0.1
Grass Hay	1.4	2.2	2.8	3.7	4.5	4.8	4.5	4.8
Legume Hay	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2
Hay/Pasture In Rotation	0.7	0.4	0.8	0.4	0.6	0.3	0.3	0.5
Irrigated	1.1	1.1	1.5	1.4	2.1	1.5	1.4	1.5
Low Residue	2.0	2.6	5.5	5.0	3.3	3.3	3.6	4.5
Other Crops	1.3	2.1	2.7	2.0	2.3	4.1	4.3	5.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	26.4	23.2	22.1	22.6	25.0	15.2	14.3	13.0
Small Grains	1.8	2.1	0.7	0.7	0.6	1.1	1.1	1.6
South Dakota	**165.6**	**159.2**	**186.0**	**235.8**	**261.6**	**290.2**	**308.9**	**316.8**
USDA Conservation Reserve Program	9.1	7.7	6.6	6.4	4.0	2.0	1.9	1.5
Fallow	8.5	8.2	5.1	4.4	3.6	4.2	4.8	3.4
Grass Hay	2.0	3.0	2.4	3.7	4.0	3.6	3.9	3.8
Legume Hay	5.1	5.3	4.2	6.0	6.3	6.6	7.1	6.8
Hay/Pasture In Rotation	5.9	6.3	6.0	9.6	7.5	5.0	4.0	4.6

Irrigated	4.7	5.4	6.0	6.9	5.9	6.3	7.0	8.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	16.2	9.0	12.9	6.7	10.4	10.1	9.6	8.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	66.8	85.9	121.3	170.7	192.7	230.9	247.2	258.5
Small Grains	47.2	28.6	21.5	21.6	27.1	21.7	23.3	21.5
Tennessee	**66.9**	**70.2**	**61.8**	**65.2**	**66.7**	**85.6**	**90.6**	**88.1**
USDA Conservation Reserve Program	1.9	2.4	1.1	1.5	1.0	1.0	0.9	0.8
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	5.3	6.5	7.1	8.8	8.0	10.4	9.8	9.2
Legume Hay	2.1	2.5	3.5	3.9	3.6	3.6	3.8	3.6
Hay/Pasture In Rotation	3.4	4.0	2.7	2.0	2.8	5.0	3.4	1.2
Irrigated	0.1	0.2	0.5	0.9	1.8	1.6	1.9	2.0
Low Residue	5.4	9.5	6.1	8.1	4.1	6.6	5.6	4.3
Other Crops	1.6	1.3	2.0	1.1	1.9	2.2	2.9	4.0
Rice	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Row Crops	46.0	43.1	38.5	37.9	42.3	53.0	59.8	61.1
Small Grains	1.0	0.8	0.4	1.0	1.0	2.2	2.5	1.8
Texas	**272.7**	**289.8**	**274.7**	**249.6**	**247.6**	**217.6**	**243.3**	**246.0**
USDA Conservation Reserve Program	16.7	21.1	16.8	20.6	16.2	14.4	16.0	16.6
Fallow	2.5	5.1	3.2	2.5	5.1	4.8	7.2	8.1
Grass Hay	5.2	3.3	4.2	4.7	8.5	9.8	10.6	12.7
Legume Hay	0.3	0.3	0.3	0.6	0.9	1.0	0.9	1.0
Hay/Pasture In Rotation	2.2	2.9	2.1	2.0	3.1	2.6	2.2	1.6
Irrigated	71.3	71.5	82.8	72.6	70.5	63.4	69.8	67.8
Low Residue	42.3	49.9	39.6	38.8	34.6	30.7	36.8	36.0
Other Crops	12.8	11.3	13.1	10.8	14.8	17.6	21.0	20.0
Rice	5.2	6.1	1.9	1.4	1.0	0.9	0.5	1.2
Row Crops	41.5	49.6	48.6	36.3	41.2	28.9	32.5	38.7
Small Grains	72.5	68.8	62.2	59.3	51.8	43.5	45.9	42.3
Utah	**9.9**	**9.5**	**9.6**	**8.5**	**8.3**	**9.7**	**11.7**	**10.3**
USDA Conservation Reserve Program	0.6	0.7	0.6	0.7	0.3	0.4	0.5	0.6
Fallow	2.0	2.6	1.4	0.8	1.0	1.0	1.2	1.5
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Hay/Pasture In Rotation	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Irrigated	6.0	5.4	6.6	6.0	5.9	6.5	7.9	6.4
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.5	0.2	0.3	0.3	0.5	1.0	0.9	1.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4
Small Grains	0.5	0.4	0.4	0.4	0.5	0.5	0.6	0.1
Vermont	**4.2**	**3.9**	**3.9**	**4.7**	**4.6**	**4.9**	**5.0**	**5.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Grass Hay	2.0	1.8	1.7	1.9	1.9	1.9	2.1	2.2
Legume Hay	0.9	1.1	0.9	1.1	1.1	1.1	0.9	1.0
Hay/Pasture In Rotation	0.4	0.4	0.5	0.7	0.4	0.6	0.6	0.5
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.8	0.7	0.8	0.9	1.1	1.1	1.4	1.6
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	**31.5**	**33.9**	**37.6**	**29.2**	**36.2**	**41.0**	**39.9**	**43.0**
USDA Conservation Reserve Program	0.2	0.2	0.3	0.2	0.1	0.2	0.2	0.2
Fallow	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Grass Hay	8.4	11.0	12.7	10.0	11.8	11.9	12.0	12.6
Legume Hay	1.7	1.8	2.8	3.0	3.3	3.1	3.2	3.4

Hay/Pasture In Rotation	2.7	1.9	2.9	1.6	2.0	1.7	1.7	1.1
Irrigated	0.9	0.8	1.4	0.8	0.6	0.7	0.8	1.0
Low Residue	1.0	1.7	1.4	1.0	0.8	1.2	1.3	1.5
Other Crops	2.3	1.7	2.1	1.4	1.6	1.8	1.5	1.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	12.7	11.9	12.9	9.3	14.1	18.6	17.4	19.5
Small Grains	1.6	2.8	1.1	1.9	1.8	1.8	1.9	2.0
Washington	**42.3**	**36.3**	**34.9**	**30.0**	**32.9**	**28.3**	**38.8**	**19.3**
USDA Conservation Reserve Program	2.5	4.4	3.0	2.8	3.9	3.0	2.3	2.2
Fallow	21.0	19.2	15.9	14.0	15.2	11.5	19.0	8.2
Grass Hay	0.7	0.8	0.5	0.6	0.6	0.7	0.7	0.7
Legume Hay	0.4	0.4	0.3	0.3	0.5	0.4	0.5	0.4
Hay/Pasture In Rotation	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Irrigated	4.4	3.2	3.6	3.1	3.1	3.6	3.7	2.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.3	0.5	1.2	0.0	0.3	1.0	1.7	1.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0
Small Grains	11.7	7.6	10.1	8.7	9.0	7.8	10.7	4.4
West Virginia	**6.9**	**6.3**	**7.9**	**9.3**	**6.4**	**6.9**	**6.5**	**5.8**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	3.8	3.4	4.5	5.6	3.5	3.4	3.0	2.9
Legume Hay	1.3	1.3	1.8	2.3	1.3	1.5	1.7	1.4
Hay/Pasture In Rotation	0.3	0.2	0.3	0.3	0.1	0.5	0.5	0.1
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.5	1.2	1.2	1.2	1.4	1.4	1.3	1.4
Small Grains	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Wisconsin	**89.6**	**85.8**	**100.3**	**110.2**	**133.6**	**115.7**	**132.5**	**132.8**
USDA Conservation Reserve Program	4.8	4.6	4.1	3.8	2.9	1.3	1.3	1.3
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	2.4	2.7	2.6	2.6	3.0	2.2	2.3	2.5
Legume Hay	5.6	4.4	4.2	5.2	5.4	4.4	4.4	4.7
Hay/Pasture In Rotation	22.1	19.4	17.1	17.3	17.2	12.1	13.5	12.3
Irrigated	0.5	0.6	0.8	1.6	2.0	1.9	2.1	1.8
Low Residue	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other Crops	9.8	7.7	6.3	6.8	6.4	5.0	5.3	3.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	42.3	45.1	64.3	72.3	96.2	88.0	103.0	106.0
Small Grains	2.0	1.4	0.7	0.6	0.6	0.8	0.7	0.6
Wyoming	**15.2**	**13.7**	**11.6**	**14.0**	**11.0**	**13.2**	**17.6**	**13.1**
USDA Conservation Reserve Program	1.1	1.0	0.6	0.8	0.6	0.5	0.7	0.5
Fallow	3.2	2.6	1.5	2.0	2.0	1.5	2.6	1.3
Grass Hay	1.6	1.3	1.0	2.0	1.4	1.8	2.5	2.0
Legume Hay	0.6	0.7	0.4	0.5	0.6	0.7	1.0	0.8
Hay/Pasture In Rotation	0.1	0.2	0.8	0.1	0.1	0.2	0.2	0.2
Irrigated	7.7	7.2	6.9	7.8	5.9	8.0	9.5	7.6
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.3	0.3	0.1	0.4	0.3	0.3	0.3	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1
Small Grains	0.6	0.4	0.3	0.5	0.3	0.2	0.4	0.2

Note: Gg CO_2 eq. is Gigagrams carbon dioxide equivalent. Estimates are only for land area that is included in Tier 3 method. Other areas are only estimated in aggregate at national scale and so State-level data are not available. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method

Appendix Table B-10 State-Level Estimates by Cropland Systems of Total Annual Indirect Nitrous Oxide Emissions From Nitrogen Leaching/Runoff, 1990, 1995, 2000, 2005, 2010, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*Gg CO2 eq.*[1]							
Alabama	**212.2**	**267.7**	**239.9**	**240.3**	**185.7**	**302.1**	**263.0**	**320.0**
USDA Conservation Reserve Program	6.0	10.1	9.5	13.8	9.7	14.6	11.1	13.2
Fallow	0.0	0.0	0.0	2.1	2.0	3.6	4.4	5.1
Grass Hay	10.5	15.0	18.1	26.6	22.3	37.3	29.8	37.6
Legume Hay	2.0	2.1	2.4	3.6	3.3	4.9	4.3	4.9
Hay/Pasture In Rotation	3.7	7.0	13.9	11.7	3.9	8.6	7.9	9.3
Irrigated	4.2	5.0	5.9	7.3	6.4	8.3	8.3	9.3
Low Residue	39.4	64.2	56.8	84.3	51.2	89.4	75.5	92.9
Other Crops	19.2	19.7	14.1	13.4	10.9	20.4	20.4	32.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	123.2	141.4	116.9	74.1	68.9	108.4	95.8	109.2
Small Grains	4.0	3.2	2.4	3.6	7.0	6.6	5.5	5.9
Arizona	**2.3**	**22.8**	**10.9**	**12.4**	**2.9**	**0.9**	**5.1**	**3.6**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	2.3	22.7	6.9	12.4	2.9	0.9	5.1	3.6
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	**1,062.0**	**824.1**	**922.5**	**652.8**	**698.1**	**1,045.2**	**964.4**	**1,086.4**
USDA Conservation Reserve Program	5.2	4.2	2.1	5.2	3.6	5.8	3.4	3.6
Fallow	3.1	0.0	6.2	5.1	12.2	20.7	20.5	21.4
Grass Hay	14.2	7.6	9.1	8.3	10.3	18.2	13.8	18.7
Legume Hay	1.5	1.0	1.0	1.5	1.6	3.2	2.3	2.9
Hay/Pasture In Rotation	0.6	2.6	1.4	1.2	0.1	1.1	0.4	0.3
Irrigated	427.4	407.7	552.9	422.5	433.3	655.9	635.4	705.1
Low Residue	82.7	57.6	52.2	13.9	9.9	21.7	14.6	9.9
Other Crops	12.7	11.8	12.5	3.9	10.2	14.8	11.8	15.5
Rice	258.7	189.6	147.6	112.1	156.5	192.5	160.5	195.6
Row Crops	235.8	125.2	118.4	61.5	52.3	97.4	86.6	94.7
Small Grains	20.1	16.8	19.1	17.5	8.1	13.8	15.2	18.7
California	**55.6**	**214.1**	**119.0**	**150.5**	**177.5**	**46.3**	**91.7**	**56.0**
USDA Conservation Reserve Program	0.0	0.0	0.6	0.7	0.0	0.0	0.0	0.0
Fallow	0.4	0.6	0.4	5.6	0.6	0.3	3.2	1.0
Grass Hay	1.7	2.6	1.7	2.1	4.0	0.6	2.7	1.5
Legume Hay	0.7	0.9	0.5	0.7	3.2	1.3	3.9	2.5
Hay/Pasture In Rotation	0.9	0.1	1.4	1.9	0.8	0.2	1.4	0.4
Irrigated	28.7	174.3	80.8	108.2	130.2	22.1	45.2	29.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.2	2.8	1.1	0.8	1.4	0.2	0.0	0.0
Rice	19.8	27.0	31.0	29.8	37.0	21.6	34.7	21.5
Row Crops	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Small Grains	3.1	5.8	1.5	0.1	0.3	0.0	0.6	0.3
Colorado	**74.1**	**171.5**	**32.0**	**116.9**	**134.9**	**81.2**	**106.9**	**170.5**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	11.8	8.5	1.2	11.7	7.6	8.9	8.1	26.3
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Hay/Pasture In Rotation	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0
Irrigated	62.2	157.6	29.1	105.0	127.2	72.2	97.1	144.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	4.7	1.5	0.0	0.2	0.0	1.7	0.0
Connecticut	**17.2**	**16.2**	**17.9**	**17.7**	**17.0**	**16.2**	**16.0**	**13.7**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Grass Hay	8.7	7.6	8.6	7.8	8.3	7.9	8.5	6.9
Legume Hay	1.4	1.2	2.6	2.7	2.6	2.0	2.4	2.2
Hay/Pasture In Rotation	0.9	0.4	0.6	1.2	0.7	0.1	0.1	0.2
Irrigated	0.0	0.0	0.0	0.1	0.3	0.3	0.3	0.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.5	0.1	0.0	0.4	0.1	0.1	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	5.8	6.6	6.0	5.5	4.9	5.8	4.2	3.7
Small Grains	0.0	0.1	0.0	0.0	0.0	0.0	0.5	0.5
Delaware	**37.4**	**37.1**	**43.3**	**37.8**	**28.8**	**48.2**	**38.3**	**40.1**
USDA Conservation Reserve Program	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.5	0.6	0.5	0.3	0.6	0.7	0.5	0.6
Legume Hay	0.3	0.1	0.1	0.3	0.2	0.2	0.2	0.2
Hay/Pasture In Rotation	0.8	0.4	0.3	0.9	0.2	0.6	0.3	0.2
Irrigated	2.3	2.5	6.2	8.2	6.8	11.4	10.8	12.0
Low Residue	0.1	0.4	0.1	0.1	0.0	0.0	0.0	0.0
Other Crops	0.4	0.4	0.1	0.3	0.2	0.4	0.4	0.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	32.6	30.3	34.9	26.6	19.7	32.2	23.3	22.1
Small Grains	0.4	2.4	1.0	1.0	1.1	2.8	2.7	4.3
Florida	**44.8**	**53.0**	**51.2**	**62.5**	**52.7**	**75.6**	**71.4**	**61.7**
USDA Conservation Reserve Program	0.8	1.3	0.9	1.1	0.9	1.2	1.0	1.1
Fallow	0.0	0.0	0.0	0.8	0.5	0.4	0.4	0.0
Grass Hay	2.2	4.2	5.3	8.9	9.4	13.5	11.5	10.4
Legume Hay	0.2	0.3	0.2	0.2	0.4	1.3	2.0	2.1
Hay/Pasture In Rotation	1.6	1.2	7.2	6.9	3.9	4.3	3.7	0.9
Irrigated	8.0	6.8	7.6	11.8	11.9	12.8	12.4	11.4
Low Residue	5.1	13.2	13.4	24.2	17.7	25.8	23.0	21.5
Other Crops	6.0	9.7	4.7	3.4	2.9	7.7	6.2	5.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	18.3	13.5	9.4	3.4	2.2	3.4	3.9	3.2
Small Grains	2.7	2.8	2.6	1.8	2.9	5.2	7.3	5.9
Georgia	**282.2**	**423.7**	**428.6**	**482.6**	**355.8**	**533.5**	**428.4**	**452.6**
USDA Conservation Reserve Program	2.9	5.5	5.3	5.8	4.8	7.6	6.8	6.8
Fallow	0.0	0.4	0.0	3.1	2.4	3.8	3.5	3.9
Grass Hay	7.2	9.6	17.4	25.9	14.6	35.8	27.6	33.4
Legume Hay	1.7	2.6	2.8	3.3	2.2	4.0	3.3	4.0
Hay/Pasture In Rotation	4.6	10.0	9.7	13.5	7.6	8.3	10.4	2.1
Irrigated	63.0	103.4	110.6	148.0	121.8	148.9	126.8	138.9
Low Residue	29.6	100.7	158.6	194.6	136.5	238.8	181.6	188.5
Other Crops	21.1	42.3	39.3	29.0	17.4	34.5	26.2	24.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	140.7	134.8	69.9	34.4	34.6	35.3	28.6	40.0
Small Grains	11.4	14.4	15.0	25.0	13.8	16.6	13.5	11.0
Idaho	**93.5**	**313.6**	**62.4**	**118.4**	**100.1**	**71.0**	**105.3**	**180.9**
USDA Conservation Reserve Program	1.5	1.6	0.8	1.0	1.3	1.3	2.1	2.0
Fallow	2.7	4.6	1.3	2.9	4.0	0.6	4.4	3.9
Grass Hay	1.3	1.7	0.8	0.7	0.9	0.8	1.0	1.2

Legume Hay	2.4	3.2	2.2	2.7	4.0	3.7	4.9	4.7
Hay/Pasture In Rotation	1.0	1.1	1.4	0.9	0.7	1.4	0.2	0.2
Irrigated	49.0	262.7	32.5	86.6	59.4	40.7	63.3	139.9
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.1	0.4	0.7	0.3	1.4	0.4	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	34.5	38.4	22.5	23.2	28.4	22.2	29.5	29.2
Illinois	**3,475.1**	**2,633.2**	**2,545.8**	**1,865.1**	**2,526.1**	**3,137.9**	**2,998.8**	**3,464.9**
USDA Conservation Reserve Program	26.7	24.2	17.4	20.8	15.8	22.8	15.5	16.5
Fallow	0.0	0.0	0.0	0.2	0.0	0.3	0.1	0.7
Grass Hay	4.3	4.2	4.2	7.3	8.0	11.8	9.5	11.4
Legume Hay	14.8	8.6	7.8	12.0	14.2	23.1	17.3	21.3
Hay/Pasture In Rotation	45.7	52.0	37.4	24.9	20.3	21.1	14.6	15.2
Irrigated	21.5	19.7	33.4	30.8	53.6	58.5	61.8	69.6
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	50.8	19.7	26.2	11.5	14.3	18.0	21.7	19.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	3,191.4	2,452.6	2,411.5	1,748.7	2,390.7	2,969.2	2,851.3	3,298.0
Small Grains	119.8	52.2	7.9	8.9	9.3	13.2	7.0	13.3
Indiana	**1,898.0**	**1,453.7**	**1,674.4**	**1,348.4**	**1,602.6**	**2,000.8**	**1,701.1**	**1,984.9**
USDA Conservation Reserve Program	16.5	12.9	6.8	6.8	3.4	4.7	3.5	3.5
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
Grass Hay	6.7	6.8	11.3	11.3	8.8	11.8	10.2	10.4
Legume Hay	17.5	10.1	15.0	18.4	19.9	31.2	25.3	24.8
Hay/Pasture In Rotation	46.4	37.5	22.5	20.7	20.1	19.9	14.9	17.1
Irrigated	21.9	21.8	29.2	26.7	31.6	38.2	35.8	39.6
Low Residue	2.1	1.5	0.3	0.5	0.4	0.8	0.4	0.9
Other Crops	85.3	32.7	16.9	8.6	4.7	8.1	3.2	2.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,645.5	1,305.8	1,557.8	1,241.9	1,508.0	1,877.5	1,601.0	1,874.4
Small Grains	56.1	24.6	14.5	13.5	5.7	8.8	6.5	11.1
Iowa	**3,221.1**	**2,419.6**	**1,464.7**	**2,240.2**	**3,516.7**	**3,008.1**	**3,345.7**	**3,296.2**
USDA Conservation Reserve Program	86.0	53.9	28.0	33.7	39.0	29.8	27.8	28.2
Fallow	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Grass Hay	8.2	13.9	3.2	10.2	18.5	16.3	17.3	19.4
Legume Hay	25.7	26.1	7.0	17.7	35.5	37.7	34.2	35.4
Hay/Pasture In Rotation	146.8	79.2	37.9	38.8	57.9	48.9	42.8	43.7
Irrigated	8.5	12.7	11.4	16.1	22.9	20.4	24.6	23.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	120.7	64.1	23.0	16.5	38.0	29.6	34.6	27.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2,780.7	2,153.5	1,352.5	2,105.0	3,302.2	2,823.4	3,162.5	3,117.9
Small Grains	44.6	16.3	1.7	2.0	2.7	2.1	2.0	1.7
Kansas	**944.7**	**1,213.2**	**689.4**	**1,114.6**	**1,197.4**	**1,224.7**	**971.2**	**1,640.7**
USDA Conservation Reserve Program	12.4	11.0	4.7	13.0	10.0	6.4	5.0	6.3
Fallow	11.8	19.7	14.2	40.7	31.8	20.5	33.4	68.8
Grass Hay	9.5	15.8	10.1	23.9	20.3	18.0	12.8	23.9
Legume Hay	11.5	19.3	8.5	24.3	23.7	20.7	11.1	25.9
Hay/Pasture In Rotation	27.5	20.8	7.3	22.7	16.0	15.6	6.6	15.7
Irrigated	202.9	299.0	191.5	231.5	303.5	247.7	266.2	444.2
Low Residue	0.0	0.0	0.0	1.3	1.1	0.0	0.0	0.0
Other Crops	43.3	21.3	22.4	17.0	21.2	20.3	12.2	21.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	323.7	404.6	243.5	471.6	499.3	563.5	451.3	709.1
Small Grains	302.1	401.7	187.2	268.5	270.6	311.9	172.5	325.4
Kentucky	**567.1**	**502.7**	**485.6**	**431.8**	**411.6**	**758.8**	**578.0**	**738.4**
USDA Conservation Reserve Program	17.3	14.7	9.2	11.0	7.3	7.9	5.9	5.3

Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	33.7	36.4	36.9	42.1	37.3	55.7	44.1	53.0
Legume Hay	51.1	46.2	57.3	61.8	57.9	90.0	69.1	86.0
Hay/Pasture In Rotation	53.6	44.0	40.1	26.2	26.6	45.3	35.3	23.2
Irrigated	0.8	2.3	7.8	5.7	3.1	4.7	4.0	5.5
Low Residue	17.2	23.4	14.8	6.5	5.7	6.1	4.3	8.5
Other Crops	22.0	14.8	10.1	6.6	9.3	27.6	20.5	22.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	351.8	303.3	296.5	259.2	251.0	475.6	370.1	490.9
Small Grains	19.6	17.6	13.0	12.8	13.4	45.8	24.8	44.0
Louisiana	**515.7**	**528.6**	**536.5**	**395.5**	**336.6**	**521.1**	**518.3**	**565.8**
USDA Conservation Reserve Program	0.6	0.9	1.6	3.0	3.7	4.9	3.9	4.4
Fallow	9.2	6.0	15.9	11.4	6.0	0.2	0.0	0.0
Grass Hay	7.0	6.5	7.4	8.9	10.2	14.5	11.8	15.6
Legume Hay	0.6	0.5	0.7	0.5	0.7	1.0	0.6	1.0
Hay/Pasture In Rotation	7.0	5.1	3.7	3.8	1.1	4.6	3.3	3.8
Irrigated	73.4	92.0	95.6	90.9	89.2	152.6	157.6	163.0
Low Residue	108.6	96.2	89.8	35.6	23.3	29.0	25.2	22.1
Other Crops	20.8	16.6	29.5	20.4	24.0	31.1	26.5	25.7
Rice	55.9	75.6	74.9	44.7	26.5	37.1	38.1	46.0
Row Crops	222.5	218.1	207.1	169.6	142.2	230.7	240.1	274.6
Small Grains	10.0	11.0	10.4	6.8	9.7	15.4	11.2	9.5
Maine	**43.9**	**31.1**	**31.6**	**44.9**	**45.1**	**35.0**	**29.4**	**29.6**
USDA Conservation Reserve Program	3.4	2.3	1.4	2.0	1.9	1.6	1.5	1.6
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	14.6	11.6	12.1	20.7	19.3	13.9	12.6	13.1
Legume Hay	6.4	4.7	5.9	7.4	6.8	5.0	4.8	5.7
Hay/Pasture In Rotation	4.4	1.4	2.4	1.2	3.1	0.1	0.6	0.4
Irrigated	0.8	0.2	0.3	0.5	0.6	0.5	0.4	0.3
Low Residue	5.6	4.7	5.6	5.2	6.0	3.9	4.0	2.1
Other Crops	4.0	1.7	0.5	1.8	2.5	5.1	1.8	1.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.3	2.6	1.3	1.2	1.0	0.8	0.6	0.7
Small Grains	3.5	1.9	2.3	4.9	4.0	4.2	3.1	4.0
Maryland	**175.0**	**174.2**	**168.1**	**155.4**	**116.3**	**176.3**	**154.0**	**167.0**
USDA Conservation Reserve Program	0.2	0.7	0.6	1.3	0.3	0.3	0.3	0.2
Fallow	0.0	0.0	0.0	0.2	1.1	1.0	0.3	0.3
Grass Hay	6.8	9.2	10.7	12.4	8.3	12.6	10.6	11.1
Legume Hay	3.2	3.8	4.8	6.1	4.2	6.6	6.7	6.5
Hay/Pasture In Rotation	11.0	8.8	10.6	16.2	6.9	6.9	5.1	4.3
Irrigated	1.5	1.8	3.2	4.9	5.0	8.1	7.7	9.1
Low Residue	3.8	3.5	0.5	0.1	0.0	0.0	0.0	0.0
Other Crops	8.0	5.5	8.3	2.9	2.3	2.6	2.3	3.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	125.6	122.4	117.4	105.9	83.5	133.0	115.3	120.3
Small Grains	15.0	18.5	11.9	5.5	4.7	5.3	5.6	11.8
Massachusetts	**20.5**	**18.8**	**20.1**	**20.3**	**18.3**	**14.9**	**18.7**	**17.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3
Grass Hay	9.7	9.6	11.3	11.5	10.5	8.5	11.6	10.6
Legume Hay	3.8	3.3	4.4	5.2	4.7	3.8	4.8	4.5
Hay/Pasture In Rotation	1.1	1.6	1.0	0.1	1.4	0.2	0.6	0.9
Irrigated	0.3	0.2	0.4	0.4	0.4	0.5	0.4	0.5
Low Residue	0.1	0.3	0.9	0.9	0.0	0.2	0.3	0.3
Other Crops	0.1	0.1	0.0	0.0	0.0	0.4	0.1	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	5.4	3.8	2.1	2.2	1.2	1.0	0.7	0.8
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**997.6**	**663.2**	**962.3**	**579.3**	**758.9**	**930.6**	**856.2**	**798.8**

USDA Conservation Reserve Program	9.5	10.7	8.9	4.6	3.5	3.3	2.4	2.1
Fallow	0.7	1.8	4.9	2.1	1.2	2.6	1.7	3.4
Grass Hay	20.2	15.4	15.7	12.0	12.2	15.4	14.4	13.5
Legume Hay	64.5	50.9	59.5	54.1	51.3	66.8	58.7	57.7
Hay/Pasture In Rotation	84.9	53.3	42.0	36.1	40.0	37.1	28.9	21.5
Irrigated	37.8	36.7	58.6	39.2	57.5	66.3	65.6	66.1
Low Residue	3.3	2.6	1.5	0.3	1.0	0.5	1.3	1.5
Other Crops	55.7	29.9	37.6	20.2	13.4	26.7	21.1	24.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	664.2	434.7	723.0	402.4	562.5	695.0	652.6	595.4
Small Grains	56.8	27.2	10.7	8.4	16.3	16.8	9.5	13.1
Minnesota	**1,647.8**	**2,045.4**	**1,197.9**	**2,010.5**	**2,286.3**	**1,830.8**	**2,259.1**	**1,711.1**
USDA Conservation Reserve Program	33.1	43.7	30.2	37.4	37.2	20.5	21.2	11.2
Fallow	1.2	10.6	13.7	2.5	3.4	7.4	3.2	2.1
Grass Hay	6.6	19.7	10.6	21.1	30.2	19.4	25.2	16.4
Legume Hay	29.7	50.5	27.9	59.8	80.2	58.7	75.4	45.5
Hay/Pasture In Rotation	92.5	105.3	43.6	96.8	80.9	60.3	69.7	43.0
Irrigated	36.1	37.0	27.6	42.4	47.0	53.1	60.3	53.0
Low Residue	2.6	18.9	1.6	2.4	2.6	1.7	2.9	0.3
Other Crops	75.5	115.9	78.0	88.0	95.0	84.1	113.6	52.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,164.0	1,290.3	744.1	1,502.1	1,742.3	1,428.4	1,754.5	1,407.3
Small Grains	206.5	353.6	220.7	158.0	167.5	97.3	133.2	79.9
Mississippi	**567.6**	**490.6**	**554.5**	**365.8**	**339.6**	**568.7**	**571.9**	**568.4**
USDA Conservation Reserve Program	15.3	21.1	16.2	19.8	18.3	24.1	20.4	21.8
Fallow	0.0	0.0	1.1	3.6	0.3	5.2	4.1	4.7
Grass Hay	3.6	8.6	11.1	15.8	14.7	21.9	20.0	20.4
Legume Hay	0.5	1.3	0.7	1.4	1.8	2.1	1.9	2.0
Hay/Pasture In Rotation	6.7	6.4	6.6	2.2	3.1	2.2	3.9	5.3
Irrigated	90.0	102.6	151.2	117.2	129.3	204.3	216.3	214.0
Low Residue	152.5	126.2	157.4	62.4	26.5	55.4	52.9	45.0
Other Crops	42.6	24.1	14.8	8.8	4.8	10.0	9.2	10.5
Rice	32.9	32.0	14.2	14.9	9.4	10.6	10.9	11.6
Row Crops	208.7	159.7	177.5	116.2	127.6	223.1	225.9	226.0
Small Grains	14.7	8.6	3.5	3.5	3.8	9.7	6.4	7.2
Missouri	**1,590.7**	**1,371.5**	**1,070.2**	**1,155.4**	**1,441.7**	**1,702.4**	**1,617.0**	**1,985.0**
USDA Conservation Reserve Program	55.3	48.5	28.0	40.3	40.5	31.2	26.8	28.5
Fallow	0.0	0.5	2.3	0.3	3.8	1.5	0.8	1.5
Grass Hay	38.1	59.1	31.4	60.6	83.2	93.7	77.5	100.3
Legume Hay	43.9	52.4	27.3	58.0	77.4	87.9	64.1	81.0
Hay/Pasture In Rotation	57.1	55.8	16.0	30.6	40.7	45.4	36.5	29.3
Irrigated	112.4	124.1	156.6	151.8	146.1	227.8	204.9	235.1
Low Residue	36.1	25.7	19.1	11.6	9.7	13.3	10.4	9.1
Other Crops	73.2	49.8	35.7	14.8	23.4	45.5	35.5	49.1
Rice	16.5	12.0	11.8	29.1	29.8	28.7	22.1	25.2
Row Crops	1,006.5	840.1	693.6	724.8	956.6	1,090.8	1,099.7	1,373.3
Small Grains	151.7	103.5	48.4	33.4	30.4	36.5	38.6	52.5
Montana	**30.7**	**90.1**	**35.9**	**53.5**	**65.6**	**78.7**	**82.7**	**44.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.5	2.2	3.0	11.2	11.2	8.9	10.8	3.6
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Irrigated	30.1	83.3	32.1	42.2	54.3	69.8	71.9	40.4
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	1.1	0.4	0.0	0.0	0.0	0.0	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Small Grains	0.0	3.4	0.3	0.0	0.1	0.0	0.0	0.0
Nebraska	**684.2**	**1,319.0**	**469.5**	**1,358.1**	**1,712.3**	**1,114.3**	**1,426.8**	**1,663.9**
USDA Conservation Reserve Program	6.6	15.7	0.5	12.1	14.7	6.6	6.1	7.6
Fallow	1.4	4.1	3.4	13.3	4.2	2.5	4.8	12.6
Grass Hay	0.2	2.8	0.2	1.7	4.4	0.6	1.1	3.2
Legume Hay	0.6	11.0	0.3	5.3	13.1	2.9	4.9	8.7
Hay/Pasture In Rotation	2.3	26.7	0.7	12.9	23.6	8.6	7.5	9.9
Irrigated	444.0	748.3	416.6	877.9	1,041.1	724.2	882.3	958.3
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	13.4	17.5	4.4	5.9	9.6	9.1	8.5	8.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	187.4	457.8	41.6	419.2	593.8	357.1	510.2	651.5
Small Grains	28.4	35.1	1.8	9.9	7.8	2.6	1.4	3.2
Nevada	**1.0**	**6.9**	**1.6**	**21.7**	**14.7**	**0.9**	**1.0**	**3.5**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	1.0	6.9	1.6	21.7	14.7	0.9	1.0	3.5
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**12.3**	**11.7**	**11.3**	**14.6**	**12.4**	**11.1**	**11.4**	**11.9**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	8.2	7.4	7.8	9.7	8.7	7.4	7.7	8.0
Legume Hay	1.6	1.4	1.7	2.3	1.9	1.3	1.6	1.7
Hay/Pasture In Rotation	0.2	0.3	0.1	1.2	0.8	0.2	0.1	0.1
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.3	2.6	1.7	1.5	1.0	2.2	2.0	2.1
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**36.1**	**33.6**	**36.2**	**30.7**	**27.5**	**34.9**	**30.4**	**28.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.8	0.6	0.5	1.1	0.4
Grass Hay	3.1	3.8	4.8	3.6	3.2	4.1	4.3	3.9
Legume Hay	1.7	3.0	3.3	3.2	2.8	3.0	3.1	2.8
Hay/Pasture In Rotation	5.3	2.1	3.7	5.9	1.9	1.8	1.4	0.8
Irrigated	0.1	0.1	0.6	1.2	1.7	2.1	1.9	2.0
Low Residue	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Other Crops	1.6	1.4	0.5	1.2	1.2	1.2	1.5	1.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	22.5	22.0	21.6	14.5	14.6	21.8	16.2	16.3
Small Grains	1.8	1.3	1.5	0.4	1.3	0.3	0.8	0.4
New Mexico	**18.9**	**22.5**	**24.4**	**23.4**	**21.7**	**31.5**	**49.7**	**82.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.1	0.1	0.2	0.3	0.0	1.5	2.0	6.0
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	18.8	22.4	23.8	23.1	21.4	30.0	47.7	76.2
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
New York	**464.3**	**367.2**	**428.9**	**441.4**	**437.0**	**441.4**	**352.8**	**405.6**
USDA Conservation Reserve Program	1.9	1.9	1.8	2.1	1.7	0.8	0.6	0.7
Fallow	2.3	0.3	0.0	0.8	4.0	3.9	3.1	4.1
Grass Hay	96.0	79.6	92.2	106.3	92.2	87.9	71.7	80.0
Legume Hay	77.4	66.2	92.7	106.0	86.7	83.8	68.5	78.0
Hay/Pasture In Rotation	109.2	77.8	82.7	93.5	71.1	55.9	41.6	46.6
Irrigated	0.5	0.2	0.2	0.1	0.1	0.0	0.0	0.0
Low Residue	1.4	1.1	0.5	0.0	0.0	0.0	0.0	0.0
Other Crops	27.4	16.9	19.4	10.4	19.7	15.9	19.0	21.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	137.8	117.2	132.1	114.2	155.1	190.8	146.4	171.5
Small Grains	10.3	6.1	7.4	8.0	6.5	2.5	1.8	3.3
North Carolina	**479.1**	**589.4**	**469.2**	**452.8**	**400.9**	**565.0**	**512.2**	**524.8**
USDA Conservation Reserve Program	1.3	2.7	1.5	2.2	1.7	1.8	2.0	2.0
Fallow	1.2	2.2	0.1	5.9	4.1	5.7	5.6	6.7
Grass Hay	11.7	14.7	25.4	28.7	22.9	37.4	30.8	38.4
Legume Hay	4.3	2.5	3.1	3.7	2.7	4.3	3.6	4.9
Hay/Pasture In Rotation	8.8	12.1	8.4	12.5	7.4	8.3	7.7	4.9
Irrigated	28.3	30.8	27.1	21.6	12.3	15.6	13.5	13.8
Low Residue	52.9	124.7	117.4	123.1	84.7	109.4	119.5	110.3
Other Crops	24.3	48.4	51.7	42.5	44.1	82.3	63.2	72.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	326.8	313.5	212.7	199.7	198.3	259.4	224.8	224.4
Small Grains	19.4	37.8	21.7	12.9	22.7	40.7	41.6	47.5
North Dakota	**8.1**	**112.8**	**67.0**	**116.2**	**90.6**	**102.7**	**102.7**	**48.8**
USDA Conservation Reserve Program	0.0	1.0	0.2	0.5	0.4	0.3	0.3	0.1
Fallow	0.3	0.0	0.4	1.1	0.4	0.0	0.0	0.0
Grass Hay	0.0	0.1	0.0	0.3	0.3	0.1	0.1	0.1
Legume Hay	0.0	0.5	0.1	0.1	0.1	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.9	0.8	1.1	0.1	0.3	0.3	0.4
Irrigated	5.1	8.0	8.4	9.9	12.4	17.7	11.6	9.5
Low Residue	0.0	0.9	0.2	0.0	0.8	0.0	0.0	0.0
Other Crops	0.1	8.1	10.9	9.5	5.6	10.2	10.2	2.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.9	51.3	34.0	77.8	67.7	72.0	77.4	35.8
Small Grains	1.6	42.0	12.0	16.0	2.7	2.2	2.9	0.9
Ohio	**1,603.7**	**1,318.0**	**1,297.6**	**1,171.5**	**1,129.9**	**1,464.7**	**1,072.9**	**1,507.7**
USDA Conservation Reserve Program	11.6	10.2	7.4	6.5	5.3	4.9	2.6	3.0
Fallow	0.0	0.0	0.0	0.0	0.4	0.3	0.1	0.3
Grass Hay	17.5	15.6	22.0	25.6	21.5	29.1	24.7	28.5
Legume Hay	29.1	23.9	37.1	43.5	39.4	49.5	41.5	46.3
Hay/Pasture In Rotation	87.8	72.4	36.9	44.6	22.8	31.5	22.3	20.3
Irrigated	2.0	1.8	1.1	1.1	1.2	1.8	1.3	2.0
Low Residue	1.9	1.9	1.7	0.3	0.2	0.1	0.1	0.1
Other Crops	80.1	48.9	37.3	29.5	16.2	21.0	16.3	20.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,260.9	1,047.2	1,145.2	1,009.2	1,015.1	1,320.0	959.8	1,378.0
Small Grains	112.8	96.1	8.8	11.2	7.8	6.6	4.0	8.5
Oklahoma	**423.3**	**441.6**	**384.2**	**308.3**	**393.1**	**441.2**	**291.3**	**677.6**
USDA Conservation Reserve Program	2.2	1.2	1.5	1.5	1.8	1.1	0.3	1.0
Fallow	0.0	0.0	0.0	0.2	1.0	2.1	2.7	9.6
Grass Hay	7.8	8.2	9.6	9.3	17.2	15.7	10.4	27.4
Legume Hay	6.3	9.4	10.8	13.0	15.4	22.1	6.8	27.4
Hay/Pasture In Rotation	10.1	5.2	12.9	13.3	15.8	1.9	3.2	8.3
Irrigated	49.8	71.9	50.4	37.1	54.5	55.0	54.9	105.6
Low Residue	6.6	6.3	3.0	0.4	0.7	0.4	0.0	0.0

Other Crops	6.4	4.6	6.1	0.5	0.8	5.6	3.7	10.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	44.3	34.3	26.1	14.4	25.6	31.8	18.8	31.1
Small Grains	289.8	300.5	263.9	218.5	260.2	305.4	190.5	456.6
Oregon	**84.1**	**114.3**	**84.5**	**89.9**	**100.3**	**55.3**	**115.4**	**88.7**
USDA Conservation Reserve Program	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.2	0.4	0.8	1.7	0.9	1.3	2.5	2.6
Grass Hay	1.9	2.6	2.1	2.8	5.2	3.0	5.9	4.7
Legume Hay	1.5	2.5	2.1	3.2	5.0	2.5	5.6	4.5
Hay/Pasture In Rotation	2.9	0.6	1.3	1.8	0.8	0.7	0.2	1.7
Irrigated	23.1	50.5	37.5	30.3	31.5	18.0	41.3	32.9
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	1.3	0.9	0.4	1.0	0.4	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.0	1.1	0.3	0.1	0.3	0.1	0.2	0.2
Small Grains	53.4	56.5	39.1	49.1	56.4	28.8	59.3	42.0
Pennsylvania	**522.4**	**424.0**	**464.9**	**435.0**	**456.8**	**495.9**	**494.3**	**536.4**
USDA Conservation Reserve Program	3.3	3.1	1.7	1.8	0.9	0.9	0.5	0.4
Fallow	0.0	0.0	0.1	0.4	0.6	2.0	2.0	2.8
Grass Hay	65.7	52.0	60.2	72.1	66.3	73.3	76.9	81.5
Legume Hay	44.2	35.3	50.8	65.1	54.0	53.8	56.2	59.4
Hay/Pasture In Rotation	111.5	90.7	100.3	83.1	78.8	55.9	48.8	54.6
Irrigated	0.2	0.2	0.2	0.6	0.5	0.8	0.7	0.6
Low Residue	0.9	0.4	0.1	0.2	0.2	0.2	0.0	0.2
Other Crops	49.2	35.2	40.9	31.8	24.9	24.7	14.9	15.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	219.7	190.1	203.8	174.6	221.3	277.1	289.0	314.4
Small Grains	27.7	16.9	6.9	5.4	9.3	7.2	5.3	6.7
Rhode Island	**1.2**	**1.0**	**1.1**	**1.3**	**1.4**	**1.3**	**1.5**	**1.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	0.6	0.5	0.6	0.6	0.7	0.6	0.7	0.6
Legume Hay	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2
Hay/Pasture In Rotation	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0
Irrigated	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.2	0.2	0.1	0.2	0.2	0.3	0.4	0.4
Small Grains	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
South Carolina	**202.3**	**262.8**	**245.2**	**266.1**	**210.6**	**313.6**	**258.6**	**268.4**
USDA Conservation Reserve Program	1.8	3.4	4.3	5.0	3.0	4.3	4.0	4.0
Fallow	0.1	1.4	1.6	5.8	0.5	1.7	0.6	0.9
Grass Hay	6.5	10.8	14.8	22.0	13.8	32.9	24.6	29.5
Legume Hay	0.5	1.6	1.7	1.9	0.9	2.4	1.9	2.4
Hay/Pasture In Rotation	4.1	3.1	5.1	3.2	3.1	2.0	2.9	3.1
Irrigated	6.5	10.6	11.1	12.6	15.8	18.3	17.0	16.0
Low Residue	18.1	28.6	48.5	49.8	31.4	53.7	46.9	53.9
Other Crops	9.2	19.1	19.0	14.7	14.4	44.8	41.2	44.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	136.9	161.7	129.2	143.7	122.7	139.8	105.2	92.6
Small Grains	18.4	22.4	10.0	7.5	5.1	13.8	14.4	21.7
South Dakota	**181.9**	**639.8**	**80.6**	**618.6**	**765.8**	**546.5**	**574.1**	**435.3**
USDA Conservation Reserve Program	2.5	10.9	4.0	12.7	8.1	2.9	2.2	0.5
Fallow	0.4	4.2	0.7	0.6	4.5	5.9	2.9	3.2
Grass Hay	0.2	2.6	0.0	1.1	2.8	0.7	0.9	0.2
Legume Hay	0.8	17.4	0.2	9.4	17.6	8.0	7.5	1.6
Hay/Pasture In Rotation	1.2	22.9	0.7	15.3	19.3	8.1	6.5	4.2
Irrigated	22.1	35.5	13.4	30.3	36.9	37.6	30.1	35.3

Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	9.8	36.2	3.0	9.7	21.1	10.8	10.5	3.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	66.2	420.3	56.5	515.3	627.0	456.0	504.1	382.4
Small Grains	78.7	89.8	2.1	24.3	28.5	16.6	9.4	4.2
Tennessee	**494.8**	**411.8**	**376.8**	**332.4**	**355.6**	**653.0**	**550.3**	**535.9**
USDA Conservation Reserve Program	15.8	13.5	6.1	8.0	5.4	7.1	5.5	4.7
Fallow	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Grass Hay	29.4	29.5	30.9	33.4	37.7	50.7	41.9	46.3
Legume Hay	22.4	26.0	33.3	34.3	35.6	46.1	38.1	42.3
Hay/Pasture In Rotation	25.5	22.4	16.6	8.7	11.4	24.8	16.4	5.5
Irrigated	0.5	1.0	2.5	4.4	7.2	14.9	14.4	14.5
Low Residue	75.8	89.9	65.9	55.4	44.2	90.2	70.1	53.3
Other Crops	15.9	8.8	13.1	6.1	14.0	27.5	22.7	30.1
Rice	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0
Row Crops	296.3	214.1	202.8	171.0	187.7	367.9	317.0	316.7
Small Grains	13.3	6.6	5.6	11.0	11.9	23.8	24.1	22.4
Texas	**783.5**	**840.2**	**980.9**	**678.6**	**1,200.1**	**762.4**	**1,072.4**	**2,006.2**
USDA Conservation Reserve Program	1.5	2.2	0.7	0.5	0.7	0.4	0.0	0.1
Fallow	9.9	33.0	31.0	13.1	33.3	29.5	36.9	58.9
Grass Hay	14.0	12.4	17.1	16.5	33.1	27.2	21.6	69.9
Legume Hay	0.6	1.2	1.5	2.0	4.4	2.8	2.4	5.4
Hay/Pasture In Rotation	9.6	5.0	3.8	3.8	12.5	12.0	7.2	10.7
Irrigated	275.3	364.4	421.1	361.1	699.8	396.5	749.6	1,032.1
Low Residue	35.7	58.0	58.0	31.2	35.5	22.5	36.6	122.1
Other Crops	41.2	35.1	44.4	31.0	37.3	56.1	58.0	103.1
Rice	43.2	43.5	18.3	16.4	9.6	12.7	4.6	9.7
Row Crops	136.4	146.8	200.0	117.3	219.5	114.4	112.4	421.8
Small Grains	216.2	138.6	185.2	85.6	114.5	88.3	43.2	172.3
Utah	**2.6**	**30.2**	**5.6**	**59.4**	**21.3**	**8.1**	**18.6**	**15.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.2	2.4	0.0	0.1	0.3	1.1
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.2	0.4	0.3	0.3	0.3	0.2	0.3	0.3
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigated	2.4	29.8	5.1	56.6	9.4	7.7	17.5	13.7
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.1	0.0	11.6	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.0
Vermont	**62.6**	**53.6**	**47.7**	**63.5**	**58.0**	**55.5**	**50.2**	**61.2**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	1.5	0.4	0.1	0.0	0.1
Grass Hay	27.3	23.2	18.5	24.3	24.4	20.6	19.5	23.0
Legume Hay	16.2	14.3	14.1	16.4	16.2	13.4	12.3	14.1
Hay/Pasture In Rotation	6.0	4.8	6.1	8.7	4.9	7.2	5.2	5.0
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.2	0.1	0.1	0.2	0.2	0.4	0.4	0.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	12.7	11.3	8.9	12.2	11.8	13.9	12.8	19.0
Small Grains	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Virginia	**244.5**	**270.1**	**259.7**	**237.8**	**218.8**	**318.3**	**254.4**	**305.3**
USDA Conservation Reserve Program	1.0	1.6	1.1	1.0	0.7	1.1	0.9	1.2
Fallow	0.0	0.0	0.0	0.0	0.4	0.9	1.0	0.9
Grass Hay	42.7	56.6	48.0	55.3	51.6	75.6	59.1	71.0
Legume Hay	18.1	20.5	25.0	30.5	31.3	42.2	33.5	41.4

Hay/Pasture In Rotation	18.7	15.7	18.5	12.9	11.3	11.0	8.6	6.1
Irrigated	10.7	12.1	12.8	8.1	6.7	8.3	7.3	7.7
Low Residue	12.2	24.3	23.9	12.6	9.3	11.6	14.4	14.6
Other Crops	18.9	16.9	16.2	13.9	11.7	14.3	13.7	18.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	104.0	95.6	99.0	76.6	77.6	130.1	97.4	121.2
Small Grains	18.2	26.9	15.0	26.9	18.2	23.3	18.6	22.6
Washington	**17.6**	**42.8**	**17.5**	**15.8**	**27.3**	**20.8**	**20.3**	**20.4**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.4	0.0	0.2	0.6	0.1	0.3
Grass Hay	3.0	3.4	2.3	3.1	3.0	3.6	4.4	4.4
Legume Hay	2.6	3.3	2.1	1.9	3.5	2.2	3.0	2.8
Hay/Pasture In Rotation	1.5	0.7	0.7	1.0	1.2	0.8	0.8	0.8
Irrigated	9.6	34.0	11.3	5.1	15.9	12.9	10.6	11.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.5	1.0	0.6	4.8	3.4	0.7	1.4	1.1
Small Grains	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0
West Virginia	**52.0**	**46.0**	**47.0**	**49.5**	**38.5**	**47.4**	**37.9**	**42.3**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	19.6	16.5	17.5	21.5	15.3	17.0	13.9	14.9
Legume Hay	13.9	12.6	16.1	18.5	13.0	16.2	14.5	15.7
Hay/Pasture In Rotation	3.0	1.3	2.0	1.5	0.9	2.1	2.2	1.4
Irrigated	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0
Low Residue	0.4	0.6	0.4	0.1	0.0	0.0	0.0	0.0
Other Crops	0.6	1.0	0.1	0.0	0.3	0.9	0.4	0.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	14.4	13.2	9.9	7.8	9.0	11.2	6.9	10.0
Small Grains	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0
Wisconsin	**1,079.8**	**964.6**	**928.2**	**617.7**	**1,172.5**	**1,059.1**	**1,153.5**	**1,107.8**
USDA Conservation Reserve Program	22.0	18.6	13.1	12.9	11.1	5.8	5.9	6.1
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	11.9	18.5	12.2	13.1	21.6	16.1	17.8	17.8
Legume Hay	70.2	66.8	44.9	51.2	82.7	71.4	77.1	76.5
Hay/Pasture In Rotation	254.2	229.9	166.2	117.3	187.3	133.1	144.5	141.6
Irrigated	6.5	6.3	7.7	9.5	16.5	17.4	18.6	17.9
Low Residue	2.2	1.8	1.4	0.8	0.0	0.0	0.0	0.0
Other Crops	143.3	112.2	80.0	47.9	68.8	54.1	59.9	45.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	535.4	486.3	593.0	359.6	774.9	748.1	819.5	794.0
Small Grains	34.2	24.3	9.7	5.5	9.6	13.0	10.3	8.4
Wyoming	**11.4**	**44.9**	**10.8**	**22.9**	**30.0**	**28.6**	**38.0**	**42.6**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.3	0.7	2.0	3.4
Grass Hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Hay/Pasture In Rotation	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5
Irrigated	11.4	44.9	10.7	22.7	29.1	27.8	36.0	38.8
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small Grains	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Note: Gg CO_2 eq. is Gigagrams carbon dioxide equivalent. Estimates are only for land area that is included in Tier 3 method. Other areas are only estimated in aggregate at national scale and so State-level data are not available. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method.

Appendix Table B-11 State-Level Estimates by Cropland Management Systems of Annual Soil Organic Carbon Stock Changes, 1990, 1995, 2000, 2005, 2010, 2013–2015.

	1990	1995	2000	2005	2010	2013	2014	2015
Cropland System	*Gg CO2 eq.*							
Alabama	**(298.9)**	**(266.8)**	**(395.4)**	**(302.3)**	**(523.2)**	**(219.1)**	**(413.4)**	**(279.2)**
USDA Conservation Reserve Program	(11.5)	(52.9)	(45.2)	(104.5)	(12.0)	(68.1)	(31.0)	(99.3)
Fallow	0.0	0.0	0.0	13.8	13.3	1.3	10.9	11.6
Grass Hay	(122.0)	(144.0)	(127.8)	(167.6)	(277.3)	(235.0)	(266.0)	(328.3)
Legume Hay	(14.8)	(4.8)	(14.6)	(28.5)	(22.4)	(20.2)	(11.2)	(31.3)
Hay/Pasture In Rotation	(8.9)	42.2	(74.5)	12.8	(10.1)	26.0	10.0	52.5
Irrigated	(5.7)	(0.3)	0.0	4.2	(10.9)	(16.8)	(18.7)	(2.6)
Low Residue	19.7	30.5	54.5	10.8	14.6	139.0	94.6	109.0
Other Crops	(57.0)	(57.4)	(25.3)	1.7	(19.2)	(35.5)	7.4	21.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(79.3)	(72.1)	(156.5)	(36.8)	(200.8)	(8.7)	(207.5)	(21.0)
Small Grains	(19.5)	(8.1)	(6.1)	(8.2)	1.5	(1.0)	(1.9)	8.5
Arizona	**(10.4)**	**13.8**	**(14.3)**	**51.0**	**108.1**	**6.4**	**62.8**	**139.5**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	2.1	0.0	(13.2)	0.4	3.4	3.9	12.5
Grass Hay	(0.0)	(0.2)	(0.5)	0.0	0.0	0.0	0.0	0.0
Legume Hay	0.0	0.0	0.0	0.0	0.0	(0.2)	0.0	0.0
Hay/Pasture In Rotation	0.0	1.0	2.3	1.8	1.2	0.1	0.0	0.0
Irrigated	(30.0)	8.3	(31.7)	65.0	124.2	25.5	34.4	97.7
Low Residue	0.0	0.0	0.0	1.2	0.0	4.3	2.1	3.5
Other Crops	19.5	2.8	15.6	(3.8)	(17.5)	(26.9)	22.2	25.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	0.0	0.0	0.2	(0.1)	0.2	0.3	0.1
Small Grains	0.1	(0.2)	0.0	(0.1)	0.0	0.0	0.0	0.0
Arkansas	**(774.8)**	**(670.1)**	**(621.4)**	**(2,148.0)**	**(1,559.5)**	**(557.2)**	**(819.9)**	**(731.7)**
USDA Conservation Reserve Program	(29.6)	(42.5)	(8.5)	(11.8)	(24.0)	(30.7)	(22.8)	(19.7)
Fallow	19.2	0.0	29.5	0.6	33.7	33.2	12.8	37.6
Grass Hay	(170.3)	(119.4)	(130.1)	(133.4)	(153.2)	(117.5)	(144.3)	(132.8)
Legume Hay	(7.6)	(7.0)	(7.5)	(7.8)	(19.9)	(11.7)	(16.7)	(30.2)
Hay/Pasture In Rotation	0.6	(0.6)	(12.1)	9.8	(3.4)	(6.1)	(2.5)	(0.6)
Irrigated	(235.9)	(276.2)	(251.0)	(1,245.7)	(695.1)	(196.0)	(462.1)	(153.0)
Low Residue	(85.1)	(92.2)	31.3	(44.6)	(29.2)	16.5	(7.5)	(12.7)
Other Crops	(42.5)	2.8	(44.5)	(29.9)	(44.3)	18.5	(29.3)	(19.0)
Rice	37.2	11.8	(167.1)	(468.0)	(538.8)	(266.7)	(109.2)	(302.5)
Row Crops	(235.1)	(96.9)	(31.4)	(224.2)	(74.2)	(8.3)	(31.4)	(100.2)
Small Grains	(25.7)	(49.9)	(30.0)	7.1	(11.1)	11.5	(7.0)	1.5
California	**(195.6)**	**54.7**	**(181.9)**	**(12.0)**	**32.4**	**188.1**	**(7.5)**	**184.2**
USDA Conservation Reserve Program	(8.4)	(3.3)	(97.8)	(52.5)	(11.7)	10.2	4.1	4.8
Fallow	11.2	55.7	21.0	56.3	5.1	39.4	0.6	4.7
Grass Hay	(14.7)	(32.2)	(28.3)	(12.2)	0.5	(5.3)	(13.9)	(2.1)
Legume Hay	(4.2)	3.1	(5.1)	7.3	(3.8)	29.0	(22.7)	11.4
Hay/Pasture In Rotation	33.0	24.6	(4.1)	(7.8)	(7.4)	3.4	12.0	(2.4)
Irrigated	(267.5)	(62.1)	(130.7)	(62.1)	35.9	119.9	3.4	74.6
Low Residue	0.0	0.0	0.0	0.0	0.0	(17.1)	(6.1)	2.5
Other Crops	12.7	1.6	22.6	(29.6)	(12.0)	(65.4)	0.9	(1.2)
Rice	6.2	47.0	69.2	58.8	46.8	54.4	22.6	34.5
Row Crops	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
Small Grains	36.1	20.4	(28.7)	27.2	(21.0)	19.6	(8.5)	57.4
Colorado	**(754.4)**	**(195.1)**	**(403.1)**	**(334.1)**	**(523.6)**	**(139.2)**	**5.0**	**110.3**
USDA Conservation Reserve Program	(463.3)	(357.8)	(342.0)	(473.6)	(492.5)	(398.8)	(400.4)	(292.0)
Fallow	81.7	374.7	254.1	329.1	333.1	440.1	412.0	389.6
Grass Hay	(9.2)	(7.7)	(6.7)	(17.5)	(14.9)	(27.1)	(27.6)	10.5
Legume Hay	(0.6)	11.0	(3.2)	(42.7)	(5.1)	(23.8)	(16.2)	(1.5)
Hay/Pasture In Rotation	2.0	(7.1)	(4.6)	(0.3)	(10.1)	(4.8)	15.7	(19.3)
Irrigated	(225.0)	(186.4)	(137.0)	(163.5)	(86.8)	10.6	(28.0)	(94.4)
Low Residue	(0.1)	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(145.0)	(30.2)	(136.3)	24.4	(242.2)	(134.2)	(9.5)	16.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	(12.7)	(13.8)	(17.5)	(27.1)	16.7	13.0	20.2	31.9
Small Grains	17.7	20.6	(9.8)	37.1	(21.9)	(14.2)	38.8	68.9
Connecticut	**(72.5)**	**(29.9)**	**(11.0)**	**(49.9)**	**(49.7)**	**(8.9)**	**(29.4)**	**(34.8)**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	(0.0)	0.0	0.0	0.0	0.0
Grass Hay	(51.3)	(35.7)	(6.7)	(34.4)	(36.9)	(8.8)	(14.9)	(30.7)
Legume Hay	(11.4)	(0.9)	2.8	(18.8)	0.1	1.6	(11.4)	(4.4)
Hay/Pasture In Rotation	(3.8)	(2.0)	(4.2)	4.0	(2.1)	(0.2)	1.3	2.3
Irrigated	0.0	0.0	(0.1)	0.7	0.2	0.7	(1.1)	2.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	1.2	(0.7)	0.0	(2.9)	(0.5)	(0.2)	(0.1)	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(7.2)	9.1	(2.8)	1.5	(10.5)	(2.0)	(3.1)	(5.7)
Small Grains	0.0	0.3	0.0	0.0	0.0	0.0	(0.2)	1.7
Delaware	**(12.7)**	**(32.7)**	**(32.7)**	**(54.1)**	**(104.3)**	**(47.2)**	**(92.4)**	**(29.9)**
USDA Conservation Reserve Program	0.0	0.0	(0.3)	0.2	(0.2)	(0.2)	(0.4)	(0.3)
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(4.1)	(4.1)	(4.4)	(4.5)	(2.8)	(2.7)	(3.6)	(3.4)
Legume Hay	(0.6)	(0.8)	1.0	(2.0)	(2.1)	(1.2)	(0.3)	(0.2)
Hay/Pasture In Rotation	5.4	0.4	(0.8)	(2.5)	(0.4)	0.2	(0.6)	(1.1)
Irrigated	1.2	(3.2)	(11.1)	(4.3)	(38.2)	(24.6)	(30.4)	(17.1)
Low Residue	0.2	(0.6)	0.9	(0.1)	0.0	0.0	0.0	0.0
Other Crops	(1.2)	0.8	(0.7)	(1.1)	(0.3)	0.9	(3.8)	1.5
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(14.7)	(26.0)	(19.0)	(40.3)	(59.9)	(20.6)	(56.4)	(17.3)
Small Grains	1.2	0.9	1.8	0.6	(0.3)	1.0	3.1	8.1
Florida	**67.9**	**22.8**	**88.2**	**303.1**	**176.8**	**93.0**	**71.4**	**185.3**
USDA Conservation Reserve Program	1.1	2.1	(6.7)	1.1	(8.8)	(10.2)	(3.0)	(11.5)
Fallow	0.0	0.0	0.0	(0.5)	2.2	1.5	1.3	0.0
Grass Hay	(10.7)	3.3	3.5	14.4	15.3	(27.3)	(21.4)	(5.8)
Legume Hay	(2.1)	(0.6)	(1.7)	0.0	0.1	(1.2)	2.8	7.7
Hay/Pasture In Rotation	30.5	(6.6)	44.1	67.6	35.6	48.5	19.2	2.9
Irrigated	3.1	(3.8)	7.6	70.9	49.8	56.3	26.1	41.7
Low Residue	25.8	30.9	24.0	125.9	56.7	12.8	42.3	57.5
Other Crops	24.6	(8.7)	5.1	8.1	18.6	17.9	12.8	48.3
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.2	4.9	6.2	4.7	5.2	(13.4)	(6.2)	9.1
Small Grains	(6.8)	1.3	6.1	10.8	2.0	8.1	(2.6)	35.4
Georgia	**(271.0)**	**481.5**	**98.7**	**212.6**	**(183.7)**	**(99.7)**	**50.5**	**359.4**
USDA Conservation Reserve Program	(33.7)	(29.5)	(9.1)	(21.9)	(15.1)	(30.7)	(20.7)	(43.7)
Fallow	0.0	3.4	0.0	16.4	6.3	(0.3)	5.4	9.7
Grass Hay	(86.6)	(49.5)	(120.6)	(73.1)	(183.5)	(167.7)	(171.8)	(155.8)
Legume Hay	(9.8)	(18.1)	(23.6)	(20.7)	(9.7)	(10.3)	(16.0)	(10.3)
Hay/Pasture In Rotation	37.1	44.6	3.4	56.1	17.9	22.7	55.7	1.2
Irrigated	21.3	239.4	37.4	107.7	(84.3)	(91.8)	43.9	103.9
Low Residue	128.5	293.4	396.0	273.0	198.6	312.6	228.2	446.6
Other Crops	(71.2)	(18.1)	(101.7)	(62.9)	(8.4)	(76.3)	(45.1)	14.1
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(235.6)	23.0	(61.3)	(6.6)	(75.4)	(44.3)	(26.2)	(27.0)
Small Grains	(21.1)	(7.0)	(21.5)	(55.4)	(30.1)	(13.6)	(2.9)	20.7
Idaho	**(937.2)**	**(782.0)**	**(697.0)**	**(497.2)**	**(521.1)**	**(561.2)**	**(521.2)**	**(333.9)**
USDA Conservation Reserve Program	(160.8)	(195.8)	(130.9)	(141.2)	(134.4)	(105.6)	(88.7)	(81.5)
Fallow	(24.1)	2.0	(1.6)	35.4	(3.0)	16.4	33.3	16.0
Grass Hay	(6.7)	(17.4)	(45.8)	(14.4)	(3.0)	(5.0)	(17.3)	(3.8)
Legume Hay	(56.7)	(45.5)	(57.7)	(50.7)	(78.8)	(90.4)	(95.1)	(70.2)
Hay/Pasture In Rotation	(45.8)	(27.0)	(31.7)	(35.0)	(2.3)	(15.5)	(8.9)	(2.7)
Irrigated	(446.5)	(342.3)	(266.8)	(181.8)	(224.7)	(244.4)	(306.8)	(142.9)
Low Residue	0.0	1.9	0.0	1.0	0.2	0.0	0.0	0.0
Other Crops	(51.9)	(41.5)	(29.1)	(9.8)	(47.2)	(76.8)	(14.4)	(36.7)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.1	(0.4)	0.0	0.0	0.0	(0.5)	(6.2)	(3.7)
Small Grains	(144.7)	(116.0)	(133.4)	(100.6)	(28.0)	(39.4)	(17.0)	(8.5)
Illinois	**(5,223.1)**	**(2,823.2)**	**(5,808.9)**	**(9,307.7)**	**(5,353.9)**	**(3,058.6)**	**(5,936.7)**	**(6,735.5)**

USDA Conservation Reserve Program	(240.9)	(401.4)	(295.2)	(306.7)	(177.3)	(143.6)	(114.9)	(94.3)
Fallow	0.0	0.0	0.0	(1.6)	0.0	(0.4)	(0.8)	2.4
Grass Hay	(83.8)	(82.0)	(142.3)	(192.9)	(143.2)	(190.8)	(180.8)	(179.0)
Legume Hay	(136.9)	(43.1)	(82.5)	(166.2)	(116.1)	(111.3)	(191.3)	(148.0)
Hay/Pasture In Rotation	(330.6)	(216.1)	(538.0)	(325.8)	(102.2)	(113.6)	(108.9)	(159.5)
Irrigated	(41.3)	(16.5)	(48.0)	(116.7)	(56.4)	(98.1)	(32.5)	(78.1)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(163.7)	(60.9)	(272.4)	(87.4)	(86.7)	(66.3)	(188.4)	(55.8)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(4,081.1)	(2,040.0)	(4,442.9)	(8,107.2)	(4,654.0)	(2,343.2)	(5,116.4)	(6,019.5)
Small Grains	(144.9)	36.8	12.6	(3.0)	(17.9)	8.7	(2.8)	(3.8)
Indiana	**(2,335.4)**	**(749.3)**	**(776.9)**	**(3,343.9)**	**(2,307.1)**	**(223.2)**	**(2,180.1)**	**(2,184.7)**
USDA Conservation Reserve Program	(96.3)	(154.8)	(52.5)	(106.7)	(33.6)	(35.3)	(25.5)	(5.5)
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.9	5.6
Grass Hay	(107.3)	(146.5)	(185.2)	(173.4)	(124.5)	(124.2)	(120.4)	(108.0)
Legume Hay	(154.3)	(113.4)	(158.0)	(221.6)	(156.4)	(207.8)	(136.6)	(193.9)
Hay/Pasture In Rotation	(272.7)	(201.1)	(140.9)	(120.1)	(89.8)	(87.5)	(34.5)	(40.5)
Irrigated	(8.7)	7.2	(35.2)	(33.6)	(2.8)	(45.8)	(49.7)	(21.3)
Low Residue	11.5	4.5	1.3	2.2	2.0	2.4	2.1	6.5
Other Crops	(482.6)	(95.1)	(96.0)	(38.1)	(28.0)	(14.7)	(6.4)	(15.4)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(1,232.8)	(45.7)	(111.2)	(2,643.2)	(1,872.6)	275.5	(1,807.5)	(1,817.9)
Small Grains	7.7	(4.4)	0.8	(9.4)	(1.3)	14.2	(2.4)	5.6
Iowa	**(6,165.6)**	**(4,280.3)**	**(3,608.7)**	**(6,217.3)**	**(4,923.7)**	**(6,300.9)**	**(3,962.6)**	**(4,276.4)**
USDA Conservation Reserve Program	(868.4)	(1163.0)	(565.2)	(581.3)	(422.7)	(360.6)	(192.5)	(189.6)
Fallow	0.0	0.0	0.0	(0.4)	0.0	0.0	0.0	0.0
Grass Hay	(197.5)	(360.7)	(296.2)	(324.5)	(331.7)	(239.4)	(168.6)	(192.1)
Legume Hay	(242.7)	(244.0)	(250.2)	(168.6)	(230.2)	(212.2)	(241.7)	(243.9)
Hay/Pasture In Rotation	(1123.5)	(557.5)	(261.8)	(425.9)	(244.6)	(323.1)	(188.7)	(339.8)
Irrigated	(27.5)	(27.8)	(32.5)	(44.7)	(31.2)	(73.5)	(26.9)	(66.7)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(682.5)	(270.5)	(458.6)	(191.9)	(269.7)	(246.2)	(152.5)	(148.3)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(2,992.9)	(1,647.3)	(1,742.4)	(4,486.5)	(3,391.2)	(4,842.6)	(2,987.9)	(3,095.1)
Small Grains	(30.5)	(9.5)	(1.8)	6.5	(2.4)	(3.3)	(3.9)	(0.9)
Kansas	**(3,719.6)**	**(2,493.9)**	**(3,691.8)**	**(3,201.3)**	**(2,905.6)**	**(824.9)**	**(695.5)**	**(745.0)**
USDA Conservation Reserve Program	(528.1)	(596.4)	(552.9)	(556.5)	(547.8)	(352.1)	(427.3)	(387.9)
Fallow	32.0	270.8	(172.8)	256.7	358.5	549.2	736.3	614.9
Grass Hay	(315.4)	(383.4)	(507.5)	(555.4)	(448.8)	(321.2)	(345.4)	(384.9)
Legume Hay	(96.2)	(141.8)	(140.3)	(169.0)	(107.8)	(123.6)	(103.3)	(110.0)
Hay/Pasture In Rotation	(218.5)	(153.1)	(140.8)	(173.6)	(113.2)	(125.4)	(43.1)	(107.0)
Irrigated	(631.7)	(409.9)	(450.7)	(390.1)	(455.0)	(310.5)	(238.2)	(126.9)
Low Residue	0.0	0.0	0.0	(1.4)	(6.0)	0.0	(0.8)	0.1
Other Crops	(300.2)	(121.3)	(382.4)	(255.6)	(298.9)	(170.8)	20.7	61.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(906.8)	(604.1)	(833.2)	(922.5)	(991.6)	(63.8)	(486.5)	(553.5)
Small Grains	(754.6)	(354.8)	(511.1)	(434.0)	(295.0)	93.3	192.1	248.7
Kentucky	**(1,586.2)**	**(937.7)**	**(1,267.7)**	**(1,292.1)**	**(1,696.6)**	**(393.9)**	**(984.1)**	**(401.8)**
USDA Conservation Reserve Program	(130.2)	(146.2)	(86.2)	(66.8)	(94.8)	(37.9)	(85.2)	(17.3)
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(487.8)	(560.4)	(493.9)	(629.0)	(604.4)	(357.9)	(359.4)	(352.4)
Legume Hay	(390.8)	(408.2)	(468.4)	(621.4)	(459.7)	(324.4)	(369.3)	(372.7)
Hay/Pasture In Rotation	(334.8)	(167.9)	(261.9)	(54.0)	(149.0)	(123.3)	(57.9)	(13.5)
Irrigated	(3.9)	7.3	13.0	(6.6)	0.5	(4.2)	(3.4)	(7.5)
Low Residue	42.2	95.2	71.0	18.5	28.2	32.6	22.4	27.1
Other Crops	(104.0)	(50.1)	(29.0)	(2.6)	(2.8)	6.5	3.1	(41.5)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(176.6)	290.9	(21.2)	70.9	(406.0)	365.5	(121.7)	335.8
Small Grains	(0.3)	1.8	8.8	(1.1)	(8.7)	49.3	(12.8)	40.1
Louisiana	**(733.3)**	**(629.2)**	**(931.6)**	**(1,203.8)**	**(1,179.9)**	**(807.0)**	**(1,114.4)**	**(1,046.9)**
USDA Conservation Reserve Program	(5.8)	3.0	4.3	(27.8)	(60.6)	(32.2)	(19.4)	(23.7)
Fallow	26.5	2.6	(2.5)	(2.1)	9.1	1.2	0.0	0.0

Grass Hay	(74.2)	(65.2)	(74.7)	(78.6)	(123.0)	(108.2)	(105.4)	(108.6)
Legume Hay	(7.9)	4.4	(3.4)	(5.6)	(8.0)	2.6	0.1	4.9
Hay/Pasture In Rotation	44.3	4.8	(43.2)	10.3	6.6	17.6	(1.7)	25.2
Irrigated	(226.0)	(250.8)	(119.2)	(326.7)	(350.1)	(164.3)	(325.2)	(165.8)
Low Residue	(180.6)	(113.5)	(56.9)	(111.6)	0.0	39.9	52.8	28.8
Other Crops	(150.3)	(91.3)	(190.8)	(169.3)	(197.4)	(115.1)	(142.1)	(145.0)
Rice	12.1	(9.9)	(150.2)	(122.5)	(138.1)	(171.4)	(114.3)	(150.9)
Row Crops	(183.8)	(136.9)	(309.7)	(363.4)	(318.4)	(279.6)	(448.5)	(488.6)
Small Grains	12.5	23.5	14.6	(6.4)	0.1	2.6	(10.6)	(23.2)
Maine	**(261.3)**	**(205.6)**	**(117.4)**	**(170.1)**	**(122.9)**	**(118.4)**	**(109.0)**	**(88.4)**
USDA Conservation Reserve Program	(104.9)	(72.9)	(12.2)	(14.2)	(1.1)	7.7	(21.3)	(0.4)
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(99.1)	(115.5)	(79.1)	(107.5)	(59.4)	(79.4)	(51.5)	(54.0)
Legume Hay	(53.8)	(33.2)	(24.2)	(47.1)	(59.8)	(15.9)	(31.7)	(38.9)
Hay/Pasture In Rotation	(30.9)	(5.1)	(24.1)	(14.9)	(10.5)	(0.7)	(7.1)	(9.3)
Irrigated	0.9	1.1	(1.2)	(2.6)	(0.3)	0.0	(2.5)	(5.1)
Low Residue	3.2	10.4	27.3	16.9	16.3	(6.0)	8.8	9.9
Other Crops	8.0	3.8	(10.7)	(2.7)	(4.2)	(23.6)	(0.9)	(12.8)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	4.0	7.4	2.2	(3.1)	2.5	0.2	(1.2)	2.5
Small Grains	11.2	(1.6)	4.7	5.1	(6.3)	(0.8)	(1.6)	19.7
Maryland	**(78.8)**	**(155.6)**	**(17.9)**	**(170.4)**	**(208.4)**	**(116.3)**	**(237.8)**	**(64.2)**
USDA Conservation Reserve Program	(0.9)	(6.0)	(3.1)	(3.2)	(2.3)	(0.1)	1.2	1.6
Fallow	0.0	0.0	0.0	0.3	3.6	(5.6)	0.4	(0.5)
Grass Hay	(41.6)	(71.4)	(71.3)	(77.3)	(76.9)	(39.9)	(63.0)	(45.4)
Legume Hay	(11.1)	(20.0)	(17.4)	(39.5)	(24.9)	(24.4)	(43.0)	(33.6)
Hay/Pasture In Rotation	(42.1)	(43.4)	(40.7)	(44.7)	(29.8)	(10.4)	(11.2)	(24.7)
Irrigated	2.1	3.3	(2.6)	(7.3)	(13.6)	(18.4)	(16.6)	4.0
Low Residue	5.8	4.5	0.2	(0.1)	0.0	0.0	0.0	0.0
Other Crops	(13.3)	2.0	17.0	(1.1)	(9.0)	(1.9)	0.7	(4.6)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(1.3)	(33.9)	85.2	7.1	(61.2)	(22.7)	(99.2)	20.0
Small Grains	23.5	9.3	14.8	(4.6)	5.7	7.1	(7.2)	19.0
Massachusetts	**(75.8)**	**(72.0)**	**(45.2)**	**(61.9)**	**(64.5)**	**(43.8)**	**(40.7)**	**(57.7)**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	(0.6)	1.2	(1.6)
Grass Hay	(44.5)	(55.1)	(35.9)	(46.1)	(43.3)	(42.0)	(28.2)	(41.4)
Legume Hay	(31.3)	(15.6)	(12.1)	(22.6)	(19.0)	(5.7)	(19.2)	(22.1)
Hay/Pasture In Rotation	(2.0)	(6.0)	(8.4)	(1.7)	(1.2)	(2.1)	0.7	2.1
Irrigated	0.0	(2.8)	0.2	1.0	1.3	1.3	1.6	(0.3)
Low Residue	0.6	2.2	8.5	7.6	0.0	1.8	2.1	1.7
Other Crops	(0.0)	1.3	0.0	0.0	(0.2)	0.3	0.0	1.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1.3	4.0	2.5	(0.1)	(2.1)	3.3	1.1	2.6
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Michigan	**(911.5)**	**(453.0)**	**7.6**	**(1,028.7)**	**(482.2)**	**(428.7)**	**(482.4)**	**(301.2)**
USDA Conservation Reserve Program	(35.5)	(98.0)	(79.8)	(50.6)	(8.6)	(30.9)	(42.4)	(26.8)
Fallow	3.6	(1.8)	21.8	1.3	2.7	(5.6)	5.5	22.3
Grass Hay	(146.8)	(156.6)	(143.8)	(168.1)	(140.5)	(119.1)	(129.1)	(142.3)
Legume Hay	(422.9)	(417.7)	(355.9)	(441.4)	(336.2)	(288.1)	(380.5)	(320.5)
Hay/Pasture In Rotation	(267.9)	(214.1)	(162.0)	(167.6)	(87.9)	(18.0)	(58.5)	(55.7)
Irrigated	(16.8)	27.5	17.2	12.6	(43.3)	(59.0)	(44.9)	5.2
Low Residue	2.0	13.5	2.3	1.9	2.7	2.8	11.3	10.5
Other Crops	(85.6)	(49.5)	9.0	(70.9)	(54.4)	8.7	(27.6)	10.9
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	40.5	412.7	682.2	(145.3)	162.3	83.0	167.6	182.5
Small Grains	17.8	31.0	16.5	(0.7)	21.1	(2.5)	16.4	12.8
Minnesota	**(2,599.5)**	**(1,146.9)**	**(1,289.5)**	**(686.6)**	**(1,733.8)**	**(5,316.6)**	**(2,472.8)**	**(1,741.7)**
USDA Conservation Reserve Program	(261.1)	(451.9)	(287.3)	(467.5)	(341.7)	(210.8)	(170.3)	(124.2)
Fallow	22.2	66.1	41.0	(0.5)	27.3	10.2	(4.2)	14.1
Grass Hay	(202.7)	(279.5)	(213.5)	(172.8)	(235.9)	(287.8)	(325.1)	(295.0)
Legume Hay	(305.9)	(277.0)	(380.9)	(250.2)	(283.7)	(448.0)	(228.0)	(274.2)
Hay/Pasture In Rotation	(562.1)	(353.0)	(379.5)	(157.6)	(171.8)	(385.1)	(243.2)	(106.4)
Irrigated	(12.3)	2.6	35.7	50.6	6.3	(83.8)	(16.0)	49.2

Low Residue	10.0	91.0	3.2	22.1	2.0	11.1	6.7	11.4
Other Crops	(301.7)	(164.1)	(4.6)	70.4	(119.4)	(118.7)	(194.2)	(43.6)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(805.5)	12.1	(227.1)	102.7	(649.6)	(3,800.8)	(1,350.9)	(925.1)
Small Grains	(180.3)	206.7	123.3	116.3	32.7	(3.0)	52.4	(47.9)
Mississippi	**(1,149.6)**	**(946.3)**	**(803.4)**	**(1,474.0)**	**(1,268.1)**	**(814.8)**	**(876.5)**	**(1,082.4)**
USDA Conservation Reserve Program	(121.3)	(194.3)	(158.2)	(170.4)	(226.8)	(152.4)	(142.2)	(154.0)
Fallow	0.0	0.0	(2.6)	1.3	(1.2)	19.2	7.1	2.6
Grass Hay	(59.2)	(126.6)	(153.4)	(207.1)	(203.3)	(180.3)	(200.6)	(269.0)
Legume Hay	1.5	(6.0)	(10.0)	(13.9)	(20.7)	(17.0)	(14.1)	(18.2)
Hay/Pasture In Rotation	(73.1)	(19.9)	(51.2)	(18.7)	1.5	4.4	(12.9)	(43.0)
Irrigated	(200.8)	(140.1)	(130.2)	(395.0)	(332.7)	(250.7)	(214.7)	(333.9)
Low Residue	(264.2)	(196.7)	(90.8)	(160.8)	(45.9)	15.3	19.8	25.0
Other Crops	(300.2)	(171.6)	(80.7)	(35.3)	(20.6)	(33.8)	(22.2)	5.2
Rice	46.7	11.7	(21.2)	(60.8)	(42.1)	(6.6)	(11.9)	16.2
Row Crops	(175.6)	(90.8)	(105.9)	(423.6)	(374.8)	(234.0)	(286.4)	(290.5)
Small Grains	(3.5)	(12.0)	0.8	10.3	(1.5)	21.4	1.5	(22.9)
Missouri	**(4,138.5)**	**(3,429.6)**	**(3,239.8)**	**(3,141.5)**	**(3,274.9)**	**(2,172.0)**	**(1,943.9)**	**(2,945.0)**
USDA Conservation Reserve Program	(514.7)	(691.2)	(529.7)	(476.0)	(412.2)	(307.6)	(198.2)	(296.3)
Fallow	0.0	6.1	15.5	2.6	5.9	1.8	4.9	1.9
Grass Hay	(864.3)	(1,355.4)	(1,342.0)	(1,152.4)	(875.8)	(978.2)	(1,032.9)	(1,200.4)
Legume Hay	(486.6)	(578.6)	(844.0)	(605.6)	(463.9)	(528.8)	(285.8)	(415.3)
Hay/Pasture In Rotation	(585.0)	(358.2)	(250.1)	(113.6)	(179.4)	(360.4)	(154.9)	(216.3)
Irrigated	(112.7)	(82.3)	(170.4)	(223.0)	(159.5)	(16.1)	(107.7)	(63.3)
Low Residue	(9.7)	(16.3)	12.5	(36.1)	(5.5)	17.6	2.2	4.1
Other Crops	(300.9)	(189.4)	(128.8)	(69.2)	(107.0)	(246.8)	(221.8)	(10.4)
Rice	30.3	32.1	(10.3)	2.7	(22.2)	3.4	3.4	(0.5)
Row Crops	(1,230.1)	(219.4)	(7.9)	(434.2)	(1,039.3)	216.2	14.3	(781.3)
Small Grains	(64.8)	23.1	15.3	(36.6)	(16.0)	26.9	32.6	32.7
Montana	**(25.1)**	**(919.3)**	**(2,450.0)**	**(1,847.6)**	**(715.2)**	**(1,674.0)**	**(978.6)**	**(1,403.8)**
USDA Conservation Reserve Program	(882.9)	(1,342.9)	(943.6)	(1,186.0)	(1,318.3)	(812.5)	(503.2)	(417.7)
Fallow	475.8	791.2	1,225.6	330.3	916.9	940.0	1,037.2	508.6
Grass Hay	(350.7)	(887.2)	(253.5)	(259.8)	(93.3)	(239.5)	(212.9)	(202.0)
Legume Hay	(351.0)	(187.0)	(143.9)	(165.7)	(161.5)	(316.8)	(330.8)	(486.8)
Hay/Pasture In Rotation	(199.2)	(241.4)	(334.5)	(205.6)	(70.3)	(53.0)	(103.1)	(57.7)
Irrigated	(583.3)	(544.4)	(1,434.3)	(605.1)	133.2	(353.1)	(258.1)	(349.1)
Low Residue	0.0	0.0	0.0	16.1	5.7	7.3	(1.8)	14.6
Other Crops	2091.8	1,866.9	(394.1)	(17.1)	(262.3)	(854.8)	(597.5)	(668.5)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	6.5	0.4	0.1	6.1	(6.6)	5.1	(2.0)	5.0
Small Grains	(232.2)	(375.1)	(171.8)	239.2	141.5	3.2	(6.4)	249.7
Nebraska	**(3,786.8)**	**(3,221.0)**	**(3,865.9)**	**(2,646.3)**	**(3,461.0)**	**(4,766.3)**	**(3,137.3)**	**(2,840.4)**
USDA Conservation Reserve Program	(339.6)	(488.5)	(307.2)	(287.0)	(293.7)	(241.9)	(153.9)	(129.4)
Fallow	80.7	96.7	(69.5)	235.2	9.0	86.2	78.1	108.5
Grass Hay	(131.1)	(153.8)	(197.5)	(212.2)	(176.4)	(200.1)	(95.0)	(197.2)
Legume Hay	(74.5)	(133.5)	(234.2)	(129.9)	(61.7)	(92.3)	(118.0)	(133.8)
Hay/Pasture In Rotation	(149.2)	(251.7)	(241.6)	(184.5)	(146.2)	(184.6)	(86.4)	(80.8)
Irrigated	(1,681.9)	(782.5)	(932.4)	(1,017.9)	(1,362.3)	(2,362.1)	(1,442.5)	(1,086.0)
Low Residue	(0.4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(472.0)	(57.5)	(137.0)	(21.8)	(119.5)	(206.5)	(111.6)	(63.9)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(918.2)	(1,387.4)	(1,701.3)	(1,048.9)	(1,321.6)	(1,557.8)	(1,197.8)	(1,264.8)
Small Grains	(100.6)	(62.8)	(45.2)	20.7	11.4	(7.3)	(10.1)	7.0
Nevada	**(82.4)**	**(1.5)**	**(86.9)**	**(64.1)**	**8.3**	**(97.8)**	**4.0**	**(2.0)**
USDA Conservation Reserve Program	(0.5)	(0.3)	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	(0.1)	(0.1)	1.3	0.0
Grass Hay	0.0	0.0	0.0	(0.3)	0.0	0.0	0.0	0.0
Legume Hay	(0.2)	(3.9)	0.5	0.1	0.0	0.0	0.1	0.1
Hay/Pasture In Rotation	0.0	0.2	(10.4)	0.3	0.1	(0.1)	(0.7)	0.0
Irrigated	(81.1)	23.1	(62.7)	(52.0)	7.4	(97.6)	5.3	(2.2)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(0.6)	(20.6)	(14.4)	(12.3)	0.9	0.0	(2.0)	1.8
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1.8)
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	**(70.4)**	**(57.4)**	**(49.1)**	**(69.6)**	**(72.6)**	**(29.7)**	**(49.2)**	**(31.8)**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(50.8)	(55.3)	(35.9)	(56.5)	(67.5)	(18.6)	(44.8)	(27.1)
Legume Hay	(14.0)	(5.6)	(12.0)	(16.1)	(6.4)	(19.1)	(8.2)	(3.1)
Hay/Pasture In Rotation	0.0	(1.8)	(1.0)	3.2	(2.3)	1.3	0.2	(2.3)
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(5.7)	5.2	(0.1)	(0.2)	3.6	6.8	3.6	0.7
Small Grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	**(39.1)**	**(68.0)**	**(34.9)**	**(2.9)**	**(28.1)**	**(1.0)**	**(16.2)**	**(52.6)**
USDA Conservation Reserve Program	0.1	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	4.7	3.0	(0.1)	0.2	2.3
Grass Hay	(18.8)	(28.4)	(18.6)	(14.0)	(20.2)	(23.2)	(25.4)	(33.5)
Legume Hay	(8.4)	(17.1)	(14.2)	(10.9)	(21.9)	(6.5)	(11.6)	(18.2)
Hay/Pasture In Rotation	(9.3)	(5.5)	(21.1)	(4.3)	(6.7)	(4.3)	(3.1)	(1.3)
Irrigated	2.1	1.3	(3.1)	(2.1)	5.5	(3.2)	6.3	2.1
Low Residue	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Other Crops	(5.1)	(7.6)	(2.6)	(3.1)	(0.1)	2.0	(3.1)	(1.3)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(5.4)	(6.6)	23.4	27.2	11.6	34.0	18.1	(3.0)
Small Grains	5.7	(4.1)	0.6	(0.3)	0.7	0.3	2.3	0.5
New Mexico	**(23.6)**	**(23.7)**	**(180.7)**	**(39.1)**	**(40.6)**	**10.5**	**146.2**	**23.3**
USDA Conservation Reserve Program	(53.2)	(76.3)	(88.6)	(80.4)	(73.2)	(77.5)	(57.9)	(87.3)
Fallow	0.8	6.8	(2.5)	3.3	11.7	14.2	10.0	15.4
Grass Hay	1.6	(9.1)	(0.5)	(0.5)	(1.6)	1.4	1.4	0.8
Legume Hay	6.4	(3.5)	(0.8)	0.2	1.9	6.0	83.4	73.5
Hay/Pasture In Rotation	(0.4)	0.2	(6.3)	0.1	(0.7)	8.4	3.8	1.4
Irrigated	(80.2)	(29.9)	(84.3)	20.6	(16.5)	10.1	14.9	(28.3)
Low Residue	12.0	6.5	0.0	(0.3)	1.9	0.8	1.3	5.9
Other Crops	9.5	(16.8)	(14.6)	0.6	0.5	(15.4)	41.7	(0.0)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(10.8)	(6.7)	(4.1)	13.2	0.0	7.4	1.8	7.2
Small Grains	90.8	105.1	20.8	4.0	35.3	55.1	45.8	34.8
New York	**(1,881.2)**	**(1,646.6)**	**(1,309.9)**	**(1,702.7)**	**(1,015.8)**	**(634.0)**	**(852.9)**	**(933.8)**
USDA Conservation Reserve Program	(12.9)	(11.9)	(11.2)	(18.2)	(28.9)	(3.3)	7.5	(8.1)
Fallow	7.5	0.6	0.0	(0.5)	12.1	26.6	15.2	15.7
Grass Hay	(854.3)	(760.1)	(736.2)	(894.8)	(634.9)	(474.0)	(590.2)	(655.7)
Legume Hay	(595.9)	(650.5)	(620.0)	(771.4)	(718.2)	(555.9)	(517.5)	(525.8)
Hay/Pasture In Rotation	(511.2)	(394.4)	(283.2)	(185.2)	(148.1)	(92.0)	(105.8)	(122.8)
Irrigated	3.9	1.4	(0.2)	0.1	(2.0)	0.0	0.0	0.0
Low Residue	1.1	6.0	(0.2)	0.0	0.0	0.0	0.0	0.0
Other Crops	(72.1)	(7.5)	(30.2)	(10.9)	11.4	(20.6)	(45.9)	14.6
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	150.3	173.3	364.6	149.6	479.8	491.3	381.6	346.0
Small Grains	2.2	(3.4)	6.7	28.5	13.1	(6.3)	2.1	2.2
North Carolina	**(414.1)**	**(394.9)**	**(201.5)**	**(539.4)**	**(1,022.5)**	**(813.4)**	**(602.0)**	**(396.5)**
USDA Conservation Reserve Program	(15.5)	(10.6)	0.8	(14.8)	(26.4)	(8.1)	(5.2)	(11.4)
Fallow	1.6	8.0	0.5	29.2	(13.6)	(0.7)	6.9	19.0
Grass Hay	(95.5)	(143.8)	(158.0)	(229.2)	(244.1)	(266.7)	(263.9)	(295.3)
Legume Hay	(24.0)	0.7	(14.1)	(9.1)	(20.1)	(12.7)	(19.4)	(19.4)
Hay/Pasture In Rotation	(0.8)	(67.3)	(74.0)	(24.3)	(38.3)	(3.6)	39.6	6.3
Irrigated	(10.5)	(17.9)	(22.6)	(20.0)	(13.1)	(18.5)	1.4	(13.2)
Low Residue	90.0	147.3	171.8	(141.5)	(40.8)	(11.5)	120.7	131.4
Other Crops	(63.5)	(15.1)	0.5	(20.5)	(88.7)	(42.7)	(53.9)	15.2
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(288.0)	(248.2)	(122.9)	(115.9)	(521.5)	(411.4)	(403.2)	(233.8)
Small Grains	(7.9)	(48.0)	16.5	6.7	(15.9)	(37.4)	(25.2)	4.8
North Dakota	**(1,561.9)**	**(1,697.8)**	**(2,832.4)**	**(2,383.5)**	**(1,979.8)**	**(3,144.9)**	**(2,741.0)**	**(3,271.6)**

USDA Conservation Reserve Program	(323.2)	(721.1)	(866.8)	(878.2)	(530.2)	(307.9)	(223.8)	(222.3)
Fallow	93.9	84.9	158.9	28.5	36.3	14.4	(9.7)	20.8
Grass Hay	(79.3)	(132.4)	(166.3)	(90.5)	(188.5)	(104.4)	(122.6)	(105.8)
Legume Hay	(309.6)	(177.4)	(228.1)	(192.9)	(271.9)	(327.9)	(312.5)	(348.4)
Hay/Pasture In Rotation	(168.0)	(243.1)	(222.8)	(176.9)	(103.7)	(146.8)	(85.2)	(167.4)
Irrigated	(3.6)	32.6	(5.5)	2.5	(4.7)	(2.9)	3.1	(2.2)
Low Residue	4.3	9.1	1.5	0.6	4.8	0.0	2.9	0.0
Other Crops	(582.3)	(164.7)	(392.1)	(204.8)	(278.2)	(894.6)	(985.7)	(781.3)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	31.5	(22.5)	29.9	131.2	(28.9)	(681.3)	199.7	(505.2)
Small Grains	(225.7)	(363.2)	(1,141.2)	(1,002.9)	(614.8)	(693.5)	(1,207.2)	(1,159.7)
Ohio	**(2,482.6)**	**(1,439.1)**	**(552.9)**	**(1,627.1)**	**(2,084.5)**	**(815.2)**	**(1,833.2)**	**(2,049.5)**
USDA Conservation Reserve Program	(35.0)	(108.6)	(79.0)	(10.8)	(49.9)	(57.7)	(41.4)	(57.5)
Fallow	0.0	0.0	0.0	0.0	2.4	0.2	(0.1)	3.0
Grass Hay	(293.4)	(392.3)	(428.6)	(411.2)	(331.6)	(267.9)	(328.2)	(298.0)
Legume Hay	(256.8)	(344.2)	(343.2)	(437.3)	(319.3)	(214.4)	(325.5)	(387.6)
Hay/Pasture In Rotation	(541.9)	(385.8)	(265.0)	(189.8)	(118.5)	(127.1)	(90.9)	(102.1)
Irrigated	(5.1)	3.7	(11.1)	(1.7)	(10.8)	(13.1)	(11.5)	(5.2)
Low Residue	6.7	3.9	11.0	(1.9)	(2.4)	(0.2)	(0.4)	1.0
Other Crops	(258.3)	(46.5)	(117.4)	(132.0)	(79.7)	(28.1)	(73.2)	(64.4)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(1,104.8)	(230.5)	676.0	(441.6)	(1,171.4)	(116.4)	(950.9)	(1,157.3)
Small Grains	6.1	61.0	4.6	(1.0)	(3.4)	9.5	(11.2)	18.6
Oklahoma	**(1,084.9)**	**(915.3)**	**(898.2)**	**(828.7)**	**(466.1)**	**169.0**	**280.1**	**476.9**
USDA Conservation Reserve Program	(204.8)	(215.6)	(227.8)	(150.8)	(157.9)	(55.3)	(62.9)	(77.0)
Fallow	5.1	3.9	(3.1)	(3.8)	6.3	10.5	27.6	29.1
Grass Hay	(107.6)	(91.4)	(102.0)	(101.8)	(207.5)	(204.1)	(205.8)	(208.4)
Legume Hay	(26.6)	(68.6)	(50.5)	(38.3)	(58.4)	(80.5)	(97.7)	(61.3)
Hay/Pasture In Rotation	(23.5)	7.1	(90.0)	37.8	53.6	(7.2)	24.2	19.3
Irrigated	(63.2)	0.4	(63.6)	(6.0)	(50.1)	1.7	14.6	(14.6)
Low Residue	(1.6)	23.6	(26.2)	(0.4)	9.3	20.2	16.5	11.3
Other Crops	2.8	11.7	(1.4)	(15.8)	1.1	1.2	(5.3)	(2.8)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(69.2)	3.7	(25.2)	(68.0)	(21.7)	13.5	(24.7)	23.4
Small Grains	(596.3)	(590.1)	(308.5)	(481.8)	(40.9)	469.0	593.6	758.1
Oregon	**(527.9)**	**(419.5)**	**(479.0)**	**(331.1)**	**(502.6)**	**(282.0)**	**(164.2)**	**(142.7)**
USDA Conservation Reserve Program	(135.0)	(118.7)	(48.7)	(73.2)	(151.3)	(56.7)	(57.1)	(97.7)
Fallow	(90.5)	(42.2)	(106.9)	(9.8)	31.2	27.6	33.0	81.2
Grass Hay	(30.5)	(57.0)	(34.2)	(41.9)	(33.9)	(29.2)	(33.1)	(44.0)
Legume Hay	(22.3)	(18.0)	(8.8)	(43.2)	(66.5)	(39.1)	(26.5)	(11.0)
Hay/Pasture In Rotation	(7.8)	1.6	(74.4)	(9.2)	(2.9)	(7.0)	1.8	(5.7)
Irrigated	(200.4)	(168.6)	(91.8)	(159.1)	(188.8)	(28.9)	11.4	(76.3)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(33.8)	(10.0)	(71.7)	(3.0)	(1.9)	(8.0)	(4.7)	1.4
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(0.8)	(2.4)	(0.4)	0.5	1.9	0.7	1.1	0.5
Small Grains	(6.9)	(4.1)	(42.3)	7.9	(90.3)	(141.7)	(90.0)	9.0
Pennsylvania	**(1,700.4)**	**(1,740.2)**	**(1,197.2)**	**(1,553.0)**	**(1,108.6)**	**(592.1)**	**(808.2)**	**(940.3)**
USDA Conservation Reserve Program	(12.6)	(38.5)	(4.0)	(26.5)	(8.9)	(5.1)	(3.7)	(6.4)
Fallow	0.0	0.0	0.8	(1.2)	0.5	0.2	8.2	12.9
Grass Hay	(630.4)	(731.7)	(696.1)	(810.3)	(663.9)	(541.3)	(657.0)	(590.9)
Legume Hay	(346.3)	(302.9)	(338.8)	(594.7)	(342.7)	(230.0)	(326.2)	(372.0)
Hay/Pasture In Rotation	(523.6)	(539.3)	(448.9)	(321.2)	(322.0)	(148.2)	(155.8)	(253.9)
Irrigated	(0.5)	(0.6)	(0.7)	(6.5)	(1.9)	0.6	(1.7)	(3.0)
Low Residue	3.0	1.8	(0.4)	(1.3)	1.5	(1.0)	0.0	0.3
Other Crops	(10.5)	(88.0)	(84.8)	13.1	(4.6)	(3.9)	(39.8)	(25.8)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(205.0)	(42.1)	367.1	189.8	221.6	323.4	370.7	289.2
Small Grains	25.3	1.0	8.5	5.7	11.9	13.3	(3.0)	9.3
Rhode Island	**(3.7)**	**(2.6)**	**(2.2)**	**(5.3)**	**0.2**	**3.9**	**0.4**	**(0.4)**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Grass Hay	(3.9)	(2.1)	(1.8)	(5.9)	0.1	1.5	(2.5)	(1.1)
Legume Hay	(1.7)	(0.1)	(1.3)	(1.5)	0.2	(0.5)	(0.5)	(0.9)
Hay/Pasture In Rotation	0.0	0.0	0.0	0.6	(2.0)	0.2	(0.2)	0.0
Irrigated	(0.8)	(0.6)	(0.8)	0.4	0.9	0.3	(0.4)	0.1
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(0.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	2.8	0.1	1.8	1.1	1.1	2.6	3.3	2.0
Small Grains	0.0	0.0	0.0	0.0	(0.1)	(0.3)	0.7	(0.4)
South Carolina	**(352.8)**	**(265.5)**	**(245.1)**	**(295.5)**	**(649.9)**	**(358.7)**	**(491.1)**	**(178.4)**
USDA Conservation Reserve Program	(16.6)	(21.9)	(2.8)	(5.1)	(0.5)	(16.9)	(27.0)	(21.1)
Fallow	0.3	6.9	(0.2)	12.3	0.4	3.8	(2.2)	1.9
Grass Hay	(62.7)	(62.6)	(68.2)	(45.2)	(146.9)	(84.3)	(142.5)	(106.8)
Legume Hay	(1.3)	0.2	(6.9)	(0.3)	0.5	4.9	(4.1)	(0.3)
Hay/Pasture In Rotation	(23.1)	(9.8)	(35.6)	(10.4)	16.8	(3.4)	2.6	1.3
Irrigated	(3.9)	(1.3)	(35.7)	(2.5)	(33.2)	(3.5)	(2.4)	13.4
Low Residue	22.1	10.2	29.5	(37.8)	(18.6)	43.5	58.9	121.3
Other Crops	(38.8)	(32.7)	(39.2)	(39.9)	(99.0)	(83.6)	(143.8)	(48.7)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(205.7)	(136.3)	(73.9)	(157.0)	(387.7)	(217.4)	(233.2)	(153.2)
Small Grains	(23.2)	(18.4)	(12.1)	(9.7)	18.4	(1.7)	2.6	13.8
South Dakota	**(2,092.9)**	**(2,290.1)**	**(3,252.6)**	**(1,551.0)**	**(1,415.8)**	**(3,060.8)**	**(2,311.0)**	**(2,039.8)**
USDA Conservation Reserve Program	(456.4)	(610.2)	(310.8)	(322.3)	(208.3)	(182.6)	(56.9)	(82.2)
Fallow	191.6	196.1	161.0	171.9	132.7	119.7	145.1	53.2
Grass Hay	(190.3)	(313.7)	(302.0)	(310.0)	(299.1)	(289.4)	(278.7)	(251.6)
Legume Hay	(390.7)	(453.6)	(380.5)	(368.6)	(423.9)	(471.9)	(366.9)	(579.9)
Hay/Pasture In Rotation	(340.1)	(466.5)	(475.6)	(295.3)	(163.4)	(163.9)	(230.6)	(138.2)
Irrigated	(169.4)	(122.7)	(55.6)	7.9	(67.6)	(114.3)	(93.8)	(11.2)
Low Residue	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(645.4)	(251.6)	(729.8)	(96.5)	(160.5)	(334.7)	(313.5)	(169.7)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(450.3)	(448.1)	(1,036.5)	(292.5)	(371.9)	(1,675.0)	(1,056.9)	(680.4)
Small Grains	354.8	180.3	(122.8)	(45.5)	146.3	51.4	(58.8)	(179.9)
Tennessee	**(1,292.2)**	**(1,178.4)**	**(1,164.1)**	**(1,576.2)**	**(1,360.6)**	**(431.2)**	**(791.2)**	**(646.6)**
USDA Conservation Reserve Program	(121.4)	(178.2)	(64.9)	(66.9)	(67.5)	(55.5)	(29.8)	(26.1)
Fallow	0.0	0.0	0.0	0.0	0.2	(0.4)	0.2	0.3
Grass Hay	(362.9)	(406.0)	(457.1)	(492.8)	(505.4)	(365.5)	(374.2)	(355.2)
Legume Hay	(140.7)	(261.3)	(296.3)	(351.1)	(264.6)	(188.1)	(207.0)	(173.0)
Hay/Pasture In Rotation	(177.1)	(111.4)	(125.4)	(61.4)	(44.2)	(75.1)	(36.8)	0.7
Irrigated	(1.4)	(0.4)	2.1	(3.7)	(21.8)	(17.1)	(7.1)	(5.2)
Low Residue	(39.2)	(15.0)	11.2	(329.0)	(9.3)	119.5	68.7	62.1
Other Crops	(65.7)	(42.7)	(70.1)	(11.9)	(14.0)	26.2	(39.4)	18.3
Rice	0.0	0.0	0.0	0.5	1.8	0.0	0.0	0.0
Row Crops	(383.1)	(163.9)	(159.0)	(250.9)	(433.6)	112.8	(177.4)	(164.8)
Small Grains	(0.7)	0.6	(4.5)	(9.0)	(2.2)	12.1	11.6	(3.6)
Texas	**(2,620.7)**	**(1,152.1)**	**(2,435.2)**	**(3,234.0)**	**1,130.0**	**1,597.1**	**2,011.7**	**1,868.7**
USDA Conservation Reserve Program	(440.7)	(689.4)	(608.0)	(633.6)	(547.2)	(269.3)	(375.7)	(485.2)
Fallow	21.6	98.7	92.9	124.5	109.8	156.1	238.4	260.1
Grass Hay	(88.4)	(108.8)	(136.7)	(259.9)	(271.4)	(460.1)	(447.3)	(410.2)
Legume Hay	(3.5)	(28.7)	(20.1)	(2.1)	(32.5)	(5.4)	(0.6)	(38.9)
Hay/Pasture In Rotation	63.8	71.5	(33.0)	83.9	7.6	(5.2)	(16.9)	25.8
Irrigated	(974.6)	(606.7)	(689.9)	(555.7)	396.2	158.5	366.7	433.5
Low Residue	(53.0)	682.9	19.3	(523.8)	815.9	877.0	963.9	900.3
Other Crops	(236.7)	(66.7)	(256.2)	(205.8)	(96.9)	5.5	(29.3)	(54.0)
Rice	(60.6)	(158.9)	(69.0)	45.2	24.6	4.3	6.3	17.4
Row Crops	(278.9)	(275.2)	(745.6)	(829.1)	182.5	381.9	454.7	343.8
Small Grains	(569.7)	(70.8)	11.1	(477.6)	541.3	753.8	851.5	876.2
Utah	**(293.7)**	**(162.7)**	**(272.9)**	**(218.8)**	**(37.4)**	**(270.7)**	**(54.2)**	**89.6**
USDA Conservation Reserve Program	(43.8)	(30.2)	(26.7)	(41.3)	(32.1)	(119.7)	(46.6)	14.0
Fallow	(3.0)	27.1	10.1	10.1	0.2	(1.2)	(1.4)	53.5
Grass Hay	(0.7)	(0.7)	(3.5)	(1.1)	1.0	(3.1)	(0.3)	0.8
Legume Hay	9.2	(10.1)	(0.2)	(14.7)	(0.3)	(1.8)	4.2	1.1
Hay/Pasture In Rotation	(1.4)	5.9	(8.6)	4.4	3.1	1.6	(0.1)	3.4
Irrigated	(214.9)	(131.0)	(176.6)	(178.2)	38.2	(56.5)	10.1	39.7

Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(30.4)	(24.0)	(72.1)	(1.3)	(47.0)	(76.5)	(53.2)	(18.5)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	0.0	2.0	0.0	(4.5)	(2.6)	(3.6)	(1.2)	(7.5)
Small Grains	(8.7)	(1.8)	4.7	7.8	2.2	(9.8)	34.5	2.9
Vermont	**(282.1)**	**(254.5)**	**(181.5)**	**(228.3)**	**(229.1)**	**(138.2)**	**(110.0)**	**(144.2)**
USDA Conservation Reserve Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.2	7.9	0.6	0.8	0.0	2.7
Grass Hay	(188.8)	(152.9)	(113.1)	(159.4)	(118.2)	(88.6)	(104.8)	(109.8)
Legume Hay	(82.3)	(87.4)	(75.1)	(91.2)	(115.6)	(85.2)	(73.7)	(57.2)
Hay/Pasture In Rotation	(28.7)	(21.4)	(14.7)	(17.7)	(13.2)	(0.2)	1.6	(21.1)
Irrigated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(1.1)	1.2	(1.3)	(1.2)	1.1	(0.2)	2.8	2.0
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	19.9	6.0	22.4	34.2	16.2	35.1	64.2	39.2
Small Grains	(1.0)	0.0	0.0	(1.0)	0.0	0.0	0.0	0.0
Virginia	**(789.6)**	**(750.4)**	**(480.9)**	**(934.0)**	**(851.6)**	**(672.4)**	**(642.6)**	**(608.2)**
USDA Conservation Reserve Program	(4.7)	(10.5)	(12.9)	5.1	(9.3)	(2.2)	(11.9)	(6.5)
Fallow	0.0	0.0	0.0	0.0	2.2	3.5	4.1	5.7
Grass Hay	(449.6)	(526.4)	(327.4)	(489.9)	(416.6)	(362.7)	(410.7)	(418.5)
Legume Hay	(106.0)	(115.6)	(162.1)	(150.3)	(128.6)	(184.7)	(154.8)	(187.2)
Hay/Pasture In Rotation	(142.0)	(102.2)	(13.8)	(81.5)	(45.3)	(55.3)	15.7	11.6
Irrigated	(6.8)	(5.9)	(8.1)	(16.4)	(10.6)	(6.8)	(10.9)	(16.9)
Low Residue	14.3	44.8	66.4	(26.0)	(19.0)	(12.2)	9.1	(7.2)
Other Crops	(60.6)	(16.2)	(2.9)	(32.2)	(40.9)	1.7	(6.9)	3.7
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(13.4)	0.1	(15.6)	(143.4)	(151.0)	(44.4)	(60.8)	2.1
Small Grains	(20.9)	(18.5)	(4.5)	0.6	(32.4)	(9.4)	(15.5)	4.8
Washington	**(763.7)**	**(662.3)**	**(592.9)**	**(446.3)**	**520.6**	**(479.9)**	**(649.4)**	**(105.2)**
USDA Conservation Reserve Program	(148.9)	(288.2)	(155.0)	(235.5)	(329.2)	(287.5)	(187.1)	(208.2)
Fallow	(193.9)	(51.2)	(190.2)	(1.5)	44.2	(27.3)	(66.4)	136.5
Grass Hay	(37.3)	(27.3)	(42.1)	(46.3)	(36.5)	(45.5)	(49.8)	(40.9)
Legume Hay	(32.6)	(46.6)	(29.9)	(41.8)	(67.1)	(48.6)	(33.1)	(44.1)
Hay/Pasture In Rotation	(5.0)	(26.4)	(7.3)	(4.0)	(26.8)	(3.2)	(8.3)	(15.3)
Irrigated	(77.5)	(76.4)	(8.3)	(10.0)	14.6	(54.0)	(9.5)	(4.9)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(76.2)	16.6	(36.1)	(5.0)	171.1	(95.9)	(201.2)	(147.8)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(2.0)	6.7	2.4	13.1	5.8	2.0	5.5	2.4
Small Grains	(190.2)	(169.5)	(126.3)	(115.4)	744.6	80.1	(99.4)	217.0
West Virginia	**(458.0)**	**(395.6)**	**(379.5)**	**(433.2)**	**(359.7)**	**(227.9)**	**(211.7)**	**(229.0)**
USDA Conservation Reserve Program	(0.6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(332.8)	(287.1)	(263.2)	(247.5)	(236.7)	(148.1)	(125.6)	(164.4)
Legume Hay	(123.0)	(116.2)	(135.4)	(159.3)	(136.0)	(102.8)	(61.1)	(83.2)
Hay/Pasture In Rotation	(18.2)	(5.2)	(8.3)	(4.0)	(8.7)	4.3	(7.6)	2.2
Irrigated	0.0	0.0	(1.9)	(1.7)	0.0	0.0	0.0	0.0
Low Residue	1.5	2.1	4.0	(2.4)	0.0	0.0	0.0	0.0
Other Crops	2.5	(4.0)	0.7	(0.1)	6.9	8.9	(3.9)	(1.5)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	12.4	15.6	25.7	(18.1)	14.7	9.8	(13.5)	17.9
Small Grains	0.0	(0.8)	(1.0)	0.0	0.0	0.0	0.0	0.0
Wisconsin	**(2,009.5)**	**(1,391.2)**	**(730.6)**	**(1,292.7)**	**436.9**	**(932.7)**	**(465.4)**	**(307.6)**
USDA Conservation Reserve Program	(153.9)	(216.0)	(200.1)	(127.2)	(65.2)	(72.5)	(64.9)	(14.8)
Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grass Hay	(165.2)	(212.1)	(205.1)	(248.8)	(166.6)	(144.9)	(181.1)	(150.2)
Legume Hay	(663.5)	(408.7)	(403.2)	(421.9)	(218.6)	(308.3)	(332.2)	(403.9)
Hay/Pasture In Rotation	(1,182.7)	(649.6)	(729.1)	(560.2)	(186.6)	(531.7)	(326.0)	(372.9)
Irrigated	(12.0)	(12.3)	(10.5)	(17.3)	(8.8)	(45.4)	19.2	(18.6)
Low Residue	9.4	11.6	12.7	8.8	0.0	0.0	0.0	0.0
Other Crops	(147.2)	(156.3)	(98.8)	(137.0)	(47.0)	(153.3)	(87.8)	(6.0)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Row Crops	289.3	258.7	904.4	195.4	1,118.2	306.4	511.2	674.6
Small Grains	16.1	(6.4)	(1.0)	15.5	11.5	17.0	(3.7)	(15.7)
Wyoming	**(502.1)**	**(491.9)**	**(472.2)**	**(273.1)**	**(185.4)**	**(589.3)**	**(100.0)**	**(130.6)**
USDA Conservation Reserve Program	(58.7)	(83.2)	(37.5)	(34.2)	(28.8)	(22.8)	(22.7)	(5.7)
Fallow	33.9	(6.6)	24.7	67.9	(15.6)	92.5	44.0	100.1
Grass Hay	(35.4)	(38.8)	(35.3)	(7.6)	62.7	12.1	(29.3)	(75.0)
Legume Hay	(99.9)	(116.5)	(62.3)	(39.5)	(20.7)	(56.7)	(94.9)	(99.2)
Hay/Pasture In Rotation	(25.2)	(14.9)	(68.6)	(6.2)	(10.2)	3.9	(4.4)	(1.0)
Irrigated	(273.5)	(248.0)	(254.1)	(234.9)	(157.4)	(605.7)	19.3	(43.2)
Low Residue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Crops	(33.4)	0.3	(18.8)	(7.5)	(14.7)	(14.3)	(7.6)	(5.0)
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Row Crops	(0.8)	1.2	(2.5)	0.4	0.1	(0.6)	(1.6)	(3.3)
Small Grains	(9.1)	14.7	(17.9)	(11.6)	(0.8)	2.2	(2.8)	1.8

Note: Gg CO_2 eq. is Gigagrams carbon dioxide equivalent. Estimates are only for land area that is included in Tier 3 method. Other areas are only estimated in aggregate at national scale and so State-level data are not available. See Appendix Table B-12 for proportion of cropland that is estimated with the Tier 3 method.

Appendix Table B-12 National and State-Level Area of Cropland Agriculture, 1990, 1995, 2000, 2005, 2010, 2013–2015

		1990	1995	2000	2005	2010	2013	2014	2015
State		*Million hectares*							
National	Cropland Area	174.4	172.6	168.6	165.7	163.2	162.7	162.5	161.9
	Tier-3 Area	140.1	140.4	139.1	137.5	136.0	135.8	135.6	135.2
	Tier-3 (%)	80.3	81.3	82.5	83.0	83.3	83.4	83.4	83.5
Alabama	Cropland Area	1.7	1.6	1.5	1.4	1.3	1.3	1.3	1.3
	Tier-3 Area	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Tier-3 (%)	59.5	63.4	69.5	72.1	75.2	77.8	79.1	79.9
Arizona	Cropland Area	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Tier-3 Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 (%)	41.8	44.5	47.1	48.3	44.3	45.3	45.8	45.6
Arkansas	Cropland Area	3.3	3.3	3.2	3.2	3.1	3.1	3.1	3.1
	Tier-3 Area	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
	Tier-3 (%)	88.0	89.2	90.3	91.7	92.5	92.4	92.3	92.2
California	Cropland Area	4.4	4.3	4.2	4.1	4.0	4.0	4.0	4.0
	Tier-3 Area	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0
	Tier-3 (%)	26.6	26.3	25.7	25.7	25.0	25.5	25.7	25.8
Colorado	Cropland Area	4.5	4.4	4.3	4.2	4.1	4.1	4.1	4.1
	Tier-3 Area	3.8	3.8	3.8	3.7	3.6	3.6	3.6	3.6
	Tier-3 (%)	86.3	86.7	87.6	88.0	88.2	88.0	88.0	88.0
Connecticut	Cropland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier-3 (%)	48.8	52.6	56.6	59.4	59.6	58.9	59.0	59.3
Delaware	Cropland Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 (%)	53.6	54.9	57.1	59.3	61.0	62.0	62.0	61.8
Florida	Cropland Area	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2
	Tier-3 Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 (%)	13.9	12.7	14.3	15.4	17.2	17.4	17.2	17.4
Georgia	Cropland Area	2.6	2.5	2.4	2.3	2.3	2.2	2.2	2.2
	Tier-3 Area	1.3	1.4	1.5	1.5	1.4	1.4	1.4	1.4
	Tier-3 (%)	50.8	54.8	62.2	63.2	63.5	63.6	63.5	63.5
Hawaii	Cropland Area	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Tier-3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier-3 (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	Cropland Area	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.5
	Tier-3 Area	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.6
	Tier-3 (%)	65.2	66.2	66.0	65.1	64.9	64.6	64.6	64.8
Illinois	Cropland Area	10.2	10.2	10.2	10.1	10.1	10.1	10.1	10.0
	Tier-3 Area	9.4	9.4	9.5	9.5	9.4	9.4	9.4	9.4
	Tier-3 (%)	91.5	92.2	92.9	93.4	93.7	93.8	93.8	93.8
Indiana	Cropland Area	5.8	5.7	5.6	5.6	5.6	5.6	5.6	5.6
	Tier-3 Area	5.1	5.1	5.1	5.0	5.1	5.1	5.1	5.1
	Tier-3 (%)	87.9	88.6	90.0	90.3	90.8	90.9	90.9	90.9
Iowa	Cropland Area	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.0

	Tier-3 Area	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.5
	Tier-3 (%)	94.4	94.7	95.1	95.3	95.5	95.5	95.6	95.5
Kansas	Cropland Area	12.2	12.1	12.0	11.9	11.7	11.6	11.7	11.6
	Tier-3 Area	11.7	11.7	11.6	11.5	11.3	11.3	11.3	11.3
	Tier-3 (%)	95.9	96.1	96.3	96.6	96.7	96.7	96.7	96.7
Kentucky	Cropland Area	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.4
	Tier-3 Area	2.0	2.0	2.1	2.1	2.1	2.2	2.2	2.2
	Tier-3 (%)	85.0	85.9	88.1	89.0	89.2	89.6	89.6	89.8
Louisiana	Cropland Area	2.5	2.4	2.3	2.3	2.2	2.2	2.2	2.2
	Tier-3 Area	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.8
	Tier-3 (%)	77.0	78.0	78.9	78.1	78.2	79.0	79.3	80.2
Maine	Cropland Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 Area	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	Tier-3 (%)	65.1	68.3	72.1	73.6	75.1	74.5	74.0	74.1
Maryland	Cropland Area	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
	Tier-3 Area	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Tier-3 (%)	69.2	72.3	77.0	78.4	79.1	79.5	79.5	79.5
Massachusetts	Cropland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 (%)	44.0	49.3	52.2	52.5	53.3	53.3	53.3	53.4
Michigan	Cropland Area	3.9	3.8	3.7	3.5	3.5	3.5	3.5	3.4
	Tier-3 Area	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5
	Tier-3 (%)	67.4	69.2	70.6	71.2	71.6	71.5	71.6	71.6
Minnesota	Cropland Area	9.7	9.6	9.4	9.4	9.3	9.3	9.3	9.2
	Tier-3 Area	7.7	7.7	7.6	7.6	7.5	7.5	7.5	7.4
	Tier-3 (%)	79.3	79.9	80.5	80.7	80.9	81.0	81.0	81.0
Mississippi	Cropland Area	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.4
	Tier-3 Area	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
	Tier-3 (%)	74.4	77.3	81.8	83.4	85.2	86.0	86.6	86.7
Missouri	Cropland Area	6.2	6.3	6.3	6.2	6.3	6.5	6.5	6.5
	Tier-3 Area	5.6	5.8	5.8	5.8	5.8	6.0	6.0	6.0
	Tier-3 (%)	90.5	91.5	92.1	92.2	92.6	92.6	92.6	92.5
Montana	Cropland Area	7.3	7.3	7.2	7.2	7.1	7.0	7.0	6.9
	Tier-3 Area	6.6	6.7	6.6	6.5	6.4	6.4	6.3	6.3
	Tier-3 (%)	90.6	90.9	91.1	91.2	91.1	91.0	91.0	90.9
Nebraska	Cropland Area	8.6	8.7	8.6	8.6	8.6	8.6	8.6	8.6
	Tier-3 Area	7.9	8.0	7.9	7.9	7.9	8.0	8.0	8.0
	Tier-3 (%)	91.7	91.9	92.1	92.2	92.3	92.4	92.3	92.3
Nevada	Cropland Area	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
	Tier-3 Area	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 (%)	64.5	70.8	77.5	79.0	77.9	77.2	77.0	76.8
New Hampshire	Cropland Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier-3 (%)	61.0	65.9	71.0	73.8	73.0	73.0	73.9	73.8
New Jersey	Cropland Area	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	Tier-3 Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Tier-3 (%)	35.6	38.9	43.1	43.5	44.6	44.2	44.3	44.3
New Mexico	Cropland Area	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8
	Tier-3 Area	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
	Tier-3 (%)	73.5	74.0	74.8	74.4	72.8	71.4	70.9	70.6
New York	Cropland Area	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1
	Tier-3 Area	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6
	Tier-3 (%)	69.8	71.9	73.9	74.9	74.7	74.7	74.7	74.7
North Carolina	Cropland Area	2.6	2.5	2.4	2.4	2.3	2.3	2.3	2.3
	Tier-3 Area	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.6
	Tier-3 (%)	62.8	65.3	69.5	68.9	68.1	67.9	68.4	68.5
North Dakota	Cropland Area	11.5	11.5	11.4	11.3	11.1	10.9	10.9	10.8
	Tier-3 Area	7.3	7.3	7.3	7.1	7.0	6.9	6.8	6.8
	Tier-3 (%)	63.5	63.7	63.6	63.4	63.3	63.0	62.9	62.7
Ohio	Cropland Area	5.2	5.1	4.9	4.8	4.8	4.7	4.8	4.7
	Tier-3 Area	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2
	Tier-3 (%)	83.3	85.3	87.1	88.2	88.7	88.7	88.8	88.9
Oklahoma	Cropland Area	4.7	4.6	4.2	4.1	4.0	4.0	4.0	3.9
	Tier-3 Area	4.4	4.3	4.0	3.9	3.8	3.8	3.8	3.7
	Tier-3 (%)	94.4	94.6	94.8	95.0	95.3	95.3	95.3	95.2
Oregon	Cropland Area	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.8
	Tier-3 Area	1.3	1.3	1.2	1.3	1.2	1.3	1.3	1.3
	Tier-3 (%)	68.1	68.6	70.4	71.6	71.6	71.7	71.8	72.2

Pennsylvania	Cropland Area	2.4	2.4	2.3	2.2	2.2	2.2	2.1	2.1
	Tier-3 Area	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7
	Tier-3 (%)	72.1	75.2	78.6	79.9	80.3	80.5	80.2	80.2
Rhode Island	Cropland Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier-3 Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tier-3 (%)	35.3	36.2	37.9	44.0	45.5	45.6	48.1	46.4
South Carolina	Cropland Area	1.4	1.3	1.3	1.2	1.1	1.1	1.1	1.1
	Tier-3 Area	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.8
	Tier-3 (%)	57.0	62.0	69.8	72.3	74.1	76.2	75.7	76.1
South Dakota	Cropland Area	7.7	7.8	7.7	7.7	7.7	7.7	7.7	7.7
	Tier-3 Area	7.1	7.2	7.2	7.2	7.2	7.1	7.2	7.2
	Tier-3 (%)	92.4	92.6	93.0	93.3	93.3	93.3	93.3	93.3
Tennessee	Cropland Area	2.2	2.2	2.1	2.0	2.1	2.1	2.1	2.1
	Tier-3 Area	1.7	1.7	1.7	1.7	1.7	1.8	1.7	1.7
	Tier-3 (%)	76.8	79.0	81.6	82.9	83.7	84.4	84.3	84.4
Texas	Cropland Area	13.5	13.1	12.4	11.8	11.2	11.1	11.1	11.0
	Tier-3 Area	12.0	11.7	11.1	10.7	10.2	10.1	10.1	10.1
	Tier-3 (%)	88.7	89.2	89.6	90.5	91.0	91.0	91.1	91.1
Utah	Cropland Area	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7
	Tier-3 Area	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Tier-3 (%)	68.8	69.7	76.6	76.1	78.4	78.9	79.0	79.2
Vermont	Cropland Area	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 Area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tier-3 (%)	86.5	88.1	89.7	91.0	91.6	91.6	91.6	91.7
Virginia	Cropland Area	1.3	1.3	1.3	1.3	1.2	1.3	1.3	1.3
	Tier-3 Area	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Tier-3 (%)	70.9	74.4	78.2	79.3	80.4	80.4	80.0	80.0
Washington	Cropland Area	3.2	3.2	3.2	3.1	3.1	3.0	3.0	3.0
	Tier-3 Area	2.2	2.2	2.2	2.1	2.1	2.0	2.1	2.1
	Tier-3 (%)	68.2	68.4	68.4	68.4	67.7	67.6	67.6	67.7
West Virginia	Cropland Area	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
	Tier-3 Area	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
	Tier-3 (%)	71.5	75.3	79.7	79.8	80.0	78.9	78.6	78.5
Wisconsin	Cropland Area	4.8	4.8	4.6	4.5	4.5	4.5	4.5	4.4
	Tier-3 Area	3.6	3.6	3.5	3.5	3.5	3.5	3.5	3.5
	Tier-3 (%)	73.7	74.9	76.0	76.8	77.6	77.9	78.1	78.2
Wyoming	Cropland Area	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Tier-3 Area	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8
	Tier-3 (%)	84.5	85.0	85.7	85.5	85.2	85.1	84.3	84.4

Note: This table also contains the area and proportion of area that is included in the Tier 3 method.

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4.1 Summary

This chapter updates national forest greenhouse gas inventories and carbon estimates, as reported in the previous edition of the USDA GHG Inventory, Chapter 4 (Smith et al. 2016). We present estimates of stocks and net annual carbon stock change on forest lands and in harvested wood products for the United States. The estimates in this chapter correspond to estimates in the recent U.S. GHG Inventory, specifically Chapter 6: Land Use, Land-Use Change, and Forestry (EPA 2020). Results are consistent with reporting recommendations of the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC 2006).

Chapter 6 (Land Use, Land-Use Change, and Forestry) of the U.S. GHG Inventory (EPA 2020) reported that carbon sequestered, or stored, in U.S. forest ecosystems and harvested wood products (HWPs) offsets approximately 11percent (774 MMT CO_2 Eq.) of total U.S. greenhouse gas emissions in 2018 (EPA 2020). These estimates represent the amount of carbon sequestered in live vegetation and accumulated in dead organic matter, and soils in forest land remaining forest land, land converted to forest land, and HWPs in 2018 alone, contributing to carbon stocks gained and lost over past years. Total carbon uptake in 2018 was estimated at 774 MMT CO_2 eq., with a 95-percent confidence interval from 957 to 591 MMT CO_2 eq. (Table 4-1). Forest ecosystems and HWPs sequestered and accumulated about 8 percent less CO_2 eq. in 2018 relative to 1990 (Tables 4-2, 4-3). The forest ecosystems included in this report are in the conterminous United States and Alaska (Map 4-1). Estimated total carbon stocks of forest ecosystems are 204,955 MMT CO_2 eq.

Forest lands of the United States constitute approximately one-third of total land area (Oswalt et al. 2019). Recently summarized data indicate that forest land area in the conterminous United States and Alaska has remained relatively stable at approximately 280 million hectares over the time series with gains and losses in forest land area each year due to land-use change (Table 4.2, EPA 2020). While forest land area has remained relatively stable since 1990, carbon stocks in forest ecosystems and HWPs have increased since 1990. Overall, the increased forest carbon sequestration and accumulation between 1990 and 2018 is due to increased carbon density (MT C per hectare of forest). The apparent increased carbon density from Table 4-2 is based on dividing total carbon stock by forest area, and this national-scale effect is influenced by more localized factors including management, disturbances, climate, and land use. The general trend of increased forest area

Table 4-1 Forest Carbon Stock Change Estimates and Uncertainty Intervals, 2018

	Estimate	95% Confidence Interval
Source	*MMT CO_2 eq.*	
Forest Land Remaining Forest Land	(564)	(746) to (383)
Land Converted to Forest Land	(111)	(122) to (99)
Harvested Wood	(99)	(126) to (75)
Total	**(774)**	**(957) to (591)**

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
Forest ecosystem carbon stock change is based on annualized estimates for 2018 from the shaded area in Map 4-1.
Parentheses (i.e., negative net annual change) indicate net increase of carbon in forest ecosystems or wood products, by convention.
Source: EPA 2020

Table 4-2 Forest Land Remaining Forest Land Carbon Stock/Stock Change and Total Forest Land Remaining Forest Land Area Estimates, 1990, 1995, 2000, 2005, 2010, 2015, and 2018

	1990	1995	2000	2005	2010	2015	2018
Annual Change				*MMT CO_2 eq. yr⁻¹*			
Forest	(610.1)	(598.7)	(572.1)	(572.6)	(556.2)	(587.4)	(564.5)
Aboveground Biomass	(425.1)	(416.1)	(392.7)	(391.3)	(391.3)	(404.6)	(385.2)
Belowground Biomass	(98.6)	(96.6)	(91.5)	(90.8)	(90.3)	(92.9)	(88.6)
Dead Wood	(81.9)	(82.8)	(82.7)	(84.1)	(83.4)	(88.4)	(86.4)
Litter	(5.0)	(3.5)	(4.5)	(5.2)	(1.4)	(3.1)	(3.1)
Soil (Mineral)	0.3	(0.1)	(1.0)	(1.8)	4.6	(0.6)	(3.3)
Soil (Organic)	(0.6)	(0.5)	(0.3)	(0.1)	4.9	1.4	1.4
Drained Organic Soil	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Harvested Wood	(123.8)	(112.2)	(93.4)	(106.0)	(69.1)	(88.7)	(98.8)
Products in Use	(54.8)	(51.7)	(31.9)	(42.6)	(7.4)	(24.6)	(31.5)
SWDS	(69.0)	(60.5)	(61.5)	(63.4)	(61.7)	(64.1)	(67.2)
Total Net Flux	(733.9)	(710.9)	(665.5)	(678.6)	(625.3)	(676.1)	(663.2)
Carbon Stocks				*MMT CO_2 eq.*			
Forest	188,934	191,978	194,925	197,581	200,430	203,248	204,955
Aboveground Biomass	43,387	45,495	47,529	49,440	51,406	53,391	54,574
Belowground Biomass	8,616	9,105	9,578	10,024	10,479	10,935	11,207
Dead Wood	7,775	8,188	8,602	8,998	9,417	9,836	10,096
Litter	13,426	13,457	13,478	13,373	13,370	13,340	13,348
Soil (Mineral)	93,999	93,999	94,002	94,008	94,019	94,012	94,003
Soil (Organic)	21,732	21,734	21,737	21,738	21,739	21,734	21,729
Harvested Wood	6,949	7,558	8,134	8,629	9,026	9,411	9,688
Products in Use	4,579	4,862	5,116	5,307	5,393	5,464	5,547
SWDS	2,370	2,696	3,018	3,322	3,633	3,947	4,141
Total Stock	195,883	199,536	203,058	206,210	209,456	212,660	214,644
Forest Area (1000 ha)	279,748	279,840	280,025	279,749	279,918	280,041	279,787

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
Forest ecosystem carbon stocks and stock changes as well as forest area are based on annualized estimates for the shaded area in Map 4-1.
Parentheses (i.e., negative net annual change) indicate net forest ecosystem or wood products sequestration, by convention. SWDS is Solid Waste Disposal Site.
MMT CO_2 eq. is million metric tons carbon dioxide equivalent. MMT CO_2 eq. yr⁻¹ is million metric tons carbon dioxide equivalent per year.
Source: EPA 2020

and carbon stocks in Table 4-2 does not hold for all regions and ownerships (Tables 4-4 and 4-5); both area and carbon stocks have decreased on other public forest lands in the North and South. In contrast, privately owned forests in the North and South have increased in forest area and total carbon stocks over that same time interval.

Stock change sequences as estimated for the carbon pools are sometimes large and variable over time; this is particularly apparent in the aboveground biomass carbon pool (Table 4-2). Carbon stock changes have been separated into forest land remaining forest land and land converted to forest land in this report. The variability in change estimates can be partitioned to individual States and specific inventories within those States (Domke et al. 2020) (Table 4.9).

Tables 4-1 and 4-2 do not explicitly include forest biomass burned for energy production and carbon sequestered by trees in urban areas, though these affect net GHG emissions. Forest biomass harvested and burned for energy is captured implicitly in the forest carbon stock change estimates reported in Tables 4-1 and 4-2. An estimated 229 MMT CO_2 eq. was harvested and burned to produce energy in 2018. This quantity of emitted CO_2 eq. is a part of energy accounting; see Chapter 3 (Energy) of EPA (2020). Trees in urban areas sequestered about 130 MMT CO_2 eq. in 2018. This quantity is reported in Chapter 6, Land Use, Land-Use Change, and Forestry of EPA (2020) but is reported separately from forest land because urban lands fall within the settlements land use category.

4.2 Background Concepts and Conventions for Reporting Forest Carbon

This chapter summarizes carbon stocks and stock changes on the approximately 280 million hectares of forest land remaining forest land and land converted to forest land located in the conterminous 48 States and Alaska that are considered managed (EPA 2020). Land designated as managed aligns with IPCC guidance for greenhouse gas inventories. The IPCC defines managed forests as those under human influence and with a potential to affect anthropogenic carbon emissions. All forest land of the conterminous

Table 4-3 Forest Land Area by Ownership and Region, 1990, 1995, 2000, 2005, 2010, 2015, and 2018

		1990	1995	2000	2005	2010	2015	2018
Region	Ownership Group	Forest land *1,000 ha*						
Pacific Coast	Federal	47,436	47,287	47,139	46,992	46,849	46,682	46,539
Pacific Coast	Other Public	2,099	2,098	2,091	2,080	2,056	2,031	2,015
Pacific Coast	Private	12,983	12,901	12,811	12,719	12,620	12,520	12,458
Rocky Mountain	Federal	32,573	32,868	33,148	33,177	33,474	33,815	34,040
Rocky Mountain	Other Public	2,657	2,627	2,648	2,535	2,532	2,562	2,547
Rocky Mountain	Private	8,834	8,851	8,856	8,807	8,846	8,848	8,864
North	Federal	6,148	6,195	6,249	6,302	6,347	6,402	6,432
North	Other Public	19,666	18,501	17,374	16,039	14,720	13,487	12,605
North	Private	46,535	47,595	48,600	49,787	50,962	51,995	52,757
South	Federal	8,036	8,126	8,217	8,307	8,396	8,481	8,532
South	Other Public	16,236	13,939	11,580	9,371	7,145	4,442	2,774
South	Private	76,545	78,852	81,311	83,632	85,972	88,777	90,223

United States is considered managed under IPCC guidance due to explicit timber and fire management (e.g., fire suppression in wilderness areas). A large proportion of conterminous U.S. forests, 67 percent (208 million hectares), are classified as timberland, meaning they meet minimum levels of productivity and are administratively available for timber harvest (Oswalt 2019).

For reporting purposes (e.g., as in Table 4-2), we classify carbon estimates in forest ecosystems into the following pools (IPCC 2006):

- Aboveground biomass, which includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage. This category includes not only live trees but also live understory.
- Belowground biomass, which includes all living biomass of coarse living roots greater than 2 mm diameter.
- Dead wood, which includes all non-living woody biomass either standing, lying on the ground (but not including litter), or in the soil.
- Litter, which includes the litter, fumic, and humic layers, and all non-living biomass with a diameter less than 7.5 cm at transect intersection lying on the ground.
- Soil organic carbon (SOC), which includes all organic material, including fine roots, in soil to a depth of 1 meter but excluding the coarse roots of the belowground pools.

The two carbon pools reported for HWPs are:

- Harvested wood products in use.
- Harvested wood products in solid waste disposal sites.

The U.S. GHG Inventory estimates of carbon in HWPs are reported at the national scale in Tables 4-1 and 4-2 and are not disaggregated to the State level.

The U.S. GHG Inventory relies on annualized estimates of forest carbon stocks within each U.S. State from 1990 to present. Many of the carbon stock summaries presented here (and some in EPA 2020) are based on the most recent per-State forest inventory data; the year of these newest data varies by State. Thus, some of our results reflect the annualized State data (EPA 2020, Domke et al. 2020), and other results are based on the most recent available forest inventory data per State.

The estimates in this chapter focus on carbon mass, but we report results as the equivalent mass of carbon dioxide by multiplying by 44/12, by convention. Reporting conventions refer to net carbon gain in forest ecosystems as a negative estimate (i.e., a net CO_2 loss from the atmosphere). Therefore, estimates in parentheses (negative estimates) represent a net annual gain in carbon accumulated within forests or harvested wood pools (e.g., Table 4-2 lists (564.5) MMT CO_2 eq. as the net amount sequestered by forest land remaining forest land in 2018).

The carbon stocks estimated in this chapter reflect lands identified as forest land remaining forest land at the time field data were collected, as well as land converted to forest land for the 20-year conversion period (where possible, EPA 2020). Thus, the stock change estimates include net change in forest land areaand separately account for land-use change. Net gains or losses within the carbon pools could result in

Table 4-4 Total Carbon Stocks 1990–2018

		1990	1995	2000	2005	2010	2015	2018
Region	Ownership group	*MMT CO_2 eq. yr^{-1}*						
Pacific Coast	Federal	53,389	53,833	54,259	54,499	54,888	55,201	55,435
Pacific Coast	Other Public	2,150	2,193	2,238	2,284	2,327	2,365	2,384
Pacific Coast	Private	10,062	10,232	10,400	10,571	10,748	10,932	11,041
Rocky Mountain	Federal	21,755	21,636	21,507	21,368	21,217	21,035	20,949
Rocky Mountain	Other Public	1,385	1,360	1,336	1,313	1,292	1,271	1,261
Rocky Mountain	Private	5,012	4,992	4,971	4,951	4,930	4,905	4,897
North	Federal	4,280	4,357	4,433	4,508	4,584	4,660	4,704
North	Other Public	9,349	9,630	9,880	10,095	10,276	10,427	10,500
North	Private	35,609	36,155	36,717	37,302	37,925	38,578	38,979
South	Federal	5,257	5,410	5,562	5,713	5,865	6,017	6,108
South	Other Public	1,155	1,720	2,177	2,529	2,790	2,933	2,957
South	Private	39,482	40,412	41,395	42,403	43,544	44,881	45,741

either exchange with the atmosphere or transfer to or from non-forest lands.

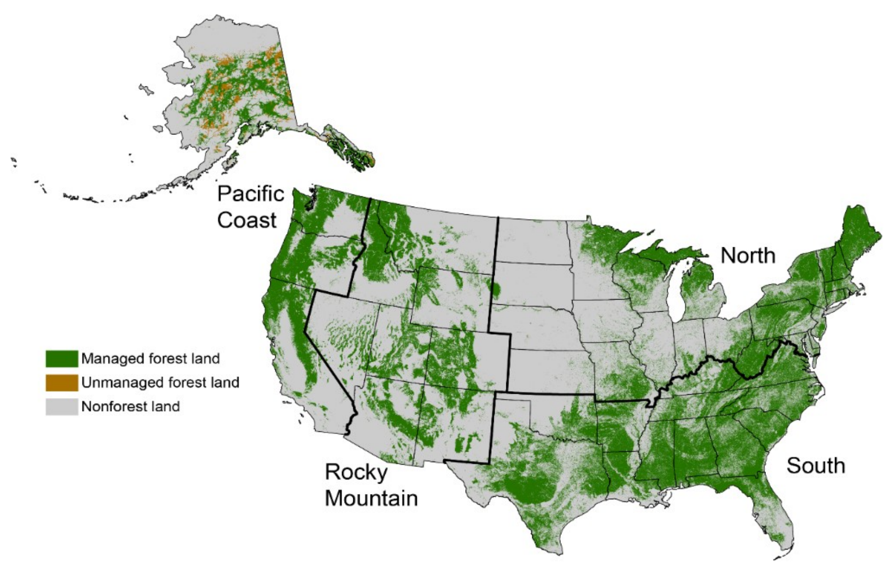
4.3 Carbon Stocks and Stock Changes by Region, State, and Ownership

The results in this chapter are reproduced or summarized from EPA 2020; specifically, Tables 4-1 and 4-2. The remaining tables are based on the same underlying inventory-based forest carbon data (developed by the authors and provided to EPA 2020 and Domke et al. 2020) but are summarized according to additional classification details not included in EPA (2020) such as ownership, regions, or State characteristics. Thus, the forest carbon estimates reported here expand on the information provided in the U.S. GHG Inventory (EPA 2020 and Domke et al. 2020) and may not align exactly with estimates in tables 4.1 and 4.2 due to rounding or State or regional disaggregation.

Table 4-3 summarizes forest land area by ownership and region. Regions are identified in Map 4-1. There are three broad classes of land ownership. Publicly owned forest lands are divided into Federally owned lands and "other public" (i.e., those under State, city, or other local government). All privately owned forest lands are combined into the third ownership classification of "private."

The majority of forest land area in the Western United States is on public lands while most forest land in the Eastern United States is on privately owned forest lands (Table 4-3). Overall forest land area has remained relatively stable, however there are some trends apparent between public and private lands. Federal forest land has remained relatively stable over the time series. Private forest land in the Eastern United States has increased over the time series while Other Public forest land has declined.

The same classifications for region and ownership were applied to disaggregated annualized stock and stock change estimates. Tables 4-4 and 4-5 describe the total annualized carbon stocks and stock changes by region. In general, the gains in total carbon stocks (Table 4-4) as well increases in annual stock change (negative values in Table 4-5) were accompanied by increases in forest area (Table 4-3). The trend toward continuous increase in stocks and area does not hold



Map 4-1 Extent of Forest Land and Woodlands (Green) by Geographic Region
Note: AK managed land follows Ogle et al. 2018. Only managed forest land was used to compile estimates in this report.

Table 4-5 Total Carbon Stock Changes 1990–2018

		1990	1995	2000	2005	2010	2015	2018
Region	Ownership group	Forest land *MMT CO_2 eq./1,000 ha*						
Pacific Coast	Federal	(84)	(86)	(87)	(56)	(73)	(72)	(88)
Pacific Coast	Other Public	(9)	(9)	(9)	(8)	(7)	(5)	(9)
Pacific Coast	Private	(34)	(34)	(35)	(36)	(37)	(35)	(34)
Rocky Mountain	Federal	25	27	29	31	25	28	23
Rocky Mountain	Other Public	5	5	4	4	3	3	5
Rocky Mountain	Private	4	5	5	5	2	2	4
North	Federal	(15)	(15)	(15)	(15)	(15)	(15)	(16)
North	Other Public	(52)	(46)	(39)	(33)	(26)	(21)	(59)
North	Private	(111)	(115)	(121)	(129)	(133)	(134)	(108)
South	Federal	(31)	(30)	(30)	(31)	(31)	(30)	(31)
South	Other Public	(99)	(77)	(58)	(39)	(13)	2	(119)
South	Private	(199)	(197)	(217)	(251)	(285)	(288)	(181)

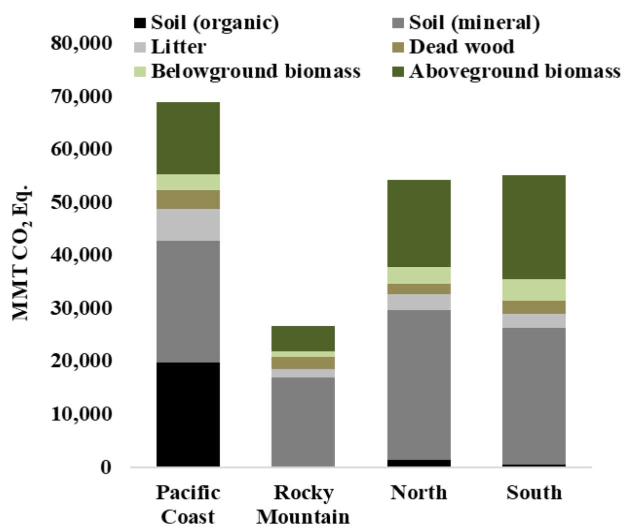


Figure 4-1 Forest Ecosystem Carbon Stocks, 2018
(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

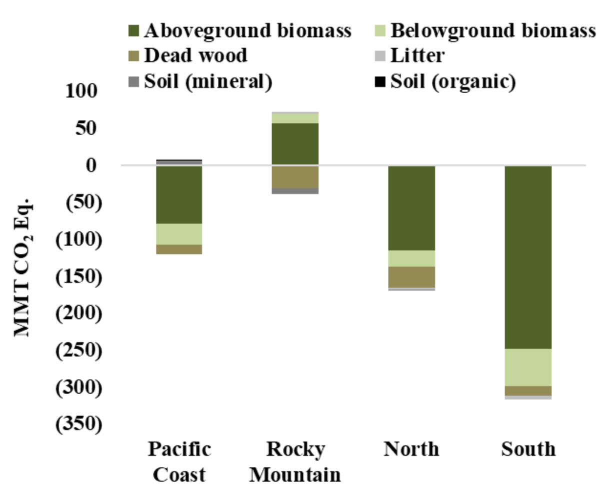


Figure 4-2 Net Annual Forest Carbon Stock Change, 2018
(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

for all regions and ownerships; both area and carbon stocks decreased in the Rocky Mountain region over the time series and the forest land area in the Other Public category in the South decreased substantially over the time series resulting in marked declines in carbon stock. Because the overall forest land area in the South has increased over the time series, it is likely that declines in Other Public land area and annual uptake reflect transfers to the Private ownership category given substantial increases in that ownership class over the time series.

Estimates of current total stocks and stock changes according to ecosystem carbon pools are illustrated in Figures 4-1 and 4-2. Table 4-6 describes plot-level carbon densities by ecosystem pools—aboveground biomass, belowground biomass, dead wood, litter, and soil (mineral and organic)—and by region and ownership. The densities—measured in metric tons (MT) CO_2 eq. per hectare—were based on the most recent survey data per State. Note that, despite the sometimes much greater carbon stock per hectare in some western forests, especially along the Pacific Coast, the larger total area of forest land in the East places those forests as the major portion of stock and change as illustrated in Figures 4-1 and 4-2. Tables 4-7 and 4-8 disaggregate the ecosystem pools for 2018 annualized data for carbon stocks (MMT CO_2 eq.) and net stock change (MMT CO_2 eq. per year). As discussed above, these stock change estimates are separately allocated according to land-use change, and corresponding stock gains or losses are separated for forest land remaining forest land and land converted to forest land Tables 4-2 and 4-9. Figure 4-3 describes State-level summaries of forest carbon stock changes by forest ecosystem carbon pool for forest land remaining forest land in 2018. These estimates are also provided in Table C-1 with State-level forest land area estimates.

Table 4-6 Carbon Densities According to Region and Ownership by Carbon Pool, 2018

Region	Ownership group	Aboveground biomass	Belowground biomass	Dead wood	Litter	Soil (mineral)	Soil (organic)	Forest area
		MT CO_2 eq. per ha						*1,000 ha*
Pacific Coast	Federal	367.2	80.9	94.6	56.2	481.6	0.3	44,076
Pacific Coast	Other Public	432.5	94.0	91.4	56.1	508.7	0.0	7,153
Pacific Coast	Private	255.4	54.6	54.9	47.3	473.8	0.3	10,498
Rocky Mountain	Federal	118.2	27.6	59.5	42.3	393.0	0.0	35,414
Rocky Mountain	Other Public	97.4	24.0	28.1	37.8	376.9	0.0	2,436
Rocky Mountain	Private	81.9	21.3	24.5	34.7	368.5	0.0	9,788
North	Federal	220.1	42.8	30.8	43.2	374.0	20.5	6,458
North	Other Public	239.6	46.3	30.7	49.0	415.1	52.2	13,297
North	Private	226.1	43.4	26.0	39.4	392.4	11.5	53,265
South	Federal	275.1	53.9	31.7	33.2	287.2	17.8	8,941
South	Other Public	381.1	74.5	44.8	54.3	441.7	44.1	1,799
South	Private	199.6	39.4	23.9	25.7	267.7	4.0	86,662

Note: MT CO_2 eq. per ha is metric tons carbon dioxide equivalent per hectare.

Table 4-7 Total Forest Ecosystem Carbon Stocks According to Region and Ownership by Carbon Pool, 2018

Region	Ownership group	Aboveground biomass	Belowground biomass	Dead wood	Litter	Soil (mineral)	Soil (organic)
				MMT CO_2 eq.			
Pacific Coast	Federal	9,556.2	2,143.4	2,643.1	5,287.0	16,065.2	19,740.1
Pacific Coast	Other Public	871.7	189.4	184.2	113.1	1,025.2	0.0
Pacific Coast	Private	3,181.5	680.1	683.9	588.7	5,903.3	3.5
Rocky Mountain	Federal	3,969.9	921.9	1,955.8	1,448.0	12,653.1	0.0
Rocky Mountain	Other Public	224.8	54.9	66.9	88.1	826.0	0.0
Rocky Mountain	Private	789.2	202.0	242.7	335.1	3,328.3	0.0
North	Federal	1,415.4	275.6	197.8	277.8	2,405.8	131.8
North	Other Public	3,020.0	584.2	387.4	618.2	5,232.4	658.4
North	Private	11,930.2	2,291.2	1,372.5	2,077.1	20,703.1	604.6
South	Federal	2,380.6	465.7	278.0	287.2	2,545.1	151.7
South	Other Public	1,073.5	209.8	127.8	152.4	12,71.0	122.2
South	Private	16,161.0	3,189.0	1,955.5	2,075.0	22,044.3	316.3

Note: MMT CO_2 eq. is million metric tons carbon dioxide equivalent.

4.4 Mechanisms of Carbon Transfer

Forest management can be defined as activities involving the regeneration, tending, protection, harvest, and utilization of forest resources to meet goals defined by the forest landowner. Forest management affects carbon stocks and stock changes through the control of mechanisms associated with carbon gain and loss. For example, increased tree volume per area of forest generally indicates increased carbon stocks.

Carbon sequestration and accumulation results from the continuous exchange of carbon dioxide between forest ecosystems or harvested wood products (HWP) and the atmosphere (Figure 4-3). Note that comprehensive greenhouse gas reporting for forests includes some non-CO_2 emissions such as methane (CH_4) and non-carbon emissions such as nitrous oxide (N_2O). Both CH_4 and N_2O can be expressed as CO_2 Eq., and in 2018 net exchange on forest land was 11.3 MMT CO_2 Eq. for CH_4 (from forest fire and drained organic soils) and 8.0 MMT CO_2 Eq. for N_2O (from forest fire, nitrogen additions to forest soils, and draining organic soils). See EPA (2020) for greater discussion on the sources of non-CO_2 emissions and methods for compiling estimates. However, the vast majority of exchange is carbon in terms of CO_2 (774 MMT CO_2 eq.), which is the focus of this chapter.

Trees accumulate carbon as they grow and remove it from the atmosphere, whereas other processes such as respiration, decomposition, or combustion remove CO_2 from forests. Forests convert much of the accumulated organic carbon to wood, which stores carbon and energy. Plant death and subsequent decomposition as well as external influences such as harvest and utilization of wood play significant roles in emissions of CO_2 from forests to the atmosphere. Mortality and disturbance emit CO_2 (e.g., from fire) and add to the pools of down dead wood and forest floor, which are also sources of emission over time following decay. Carbon can also be removed from

Table 4-8 Net Annual Forest Ecosystem Carbon Stock Change According to Region and Ownership by Carbon Pool, 2018

Region	Ownership group	Aboveground biomass	Belowground biomass	Dead wood	Litter	Soil (mineral)	Soil (organic)
				MMT CO_2 eq. yr⁻¹			
Pacific Coast	Federal	(48.9)	(21.7)	(8.8)	2.0	4.9	1.0
Pacific Coast	Other Public	(3.8)	(0.8)	(0.9)	0.0	0.2	(0.0)
Pacific Coast	Private	(26.1)	(5.7)	(3.5)	(0.1)	0.0	0.0
Rocky Mountain	Federal	50.6	11.2	(30.0)	3.1	(7.2)	0.0
Rocky Mountain	Other Public	3.1	0.7	(0.4)	0.1	(0.3)	0.0
Rocky Mountain	Private	3.3	0.7	(1.2)	(0.1)	(0.4)	0.0
North	Federal	(9.1)	(1.8)	(3.5)	(0.2)	(0.1)	(0.0)
North	Other Public	(13.2)	(2.6)	(5.2)	(0.2)	0.2	0.2
North	Private	(92.5)	(17.9)	(20.3)	(2.1)	(1.4)	0.1
South	Federal	(24.2)	(4.8)	(1.1)	(0.3)	(0.2)	0.0
South	Other Public	0.6	0.2	1.2	0.1	(0.4)	0.0
South	Private	(225.0)	(46.1)	(12.8)	(5.4)	1.1	0.1

Note: MMT CO_2 eq. yr^{-1} is million metric tons carbon dioxide equivalent per year.
See EPA (2020) for additional details on how classifications are defined.
Summaries are based on forest inventories for the shaded area in Map 4-1.
Parentheses (i.e., negative net annual change) indicate net forest ecosystem sequestration, by convention.

forest ecosystems through run-off or leaching through soil. Wood products that are removed from the forest retain carbon in the form of wood until it is eventually released and can lengthen the time before carbon returns to the atmosphere. Harvested wood products emit CO_2 through either burning or decay (Figure 4-3), and the net release of carbon from wood products depends on the product, its end use, and the means of disposal; however, the expected lifespan of wood products can vary considerably (Smith et al. 2006, Skog 2008). Harvested wood can also be used to displace non-renewable fuel sources, with or without energy capture. There are additional utilization pathways for harvested wood products that provide opportunities to reduce emissions and increase sequestration, such as substituting for non-renewable materials (Perez-Garcia et al. 2005, Geng et al. 2017). While there are transfers of carbon between the atmosphere and live and dead organic matter and soils in forest ecosystem and harvested wood products, there are also transfers of carbon resulting from land conversions. Land conversion to and from forests has

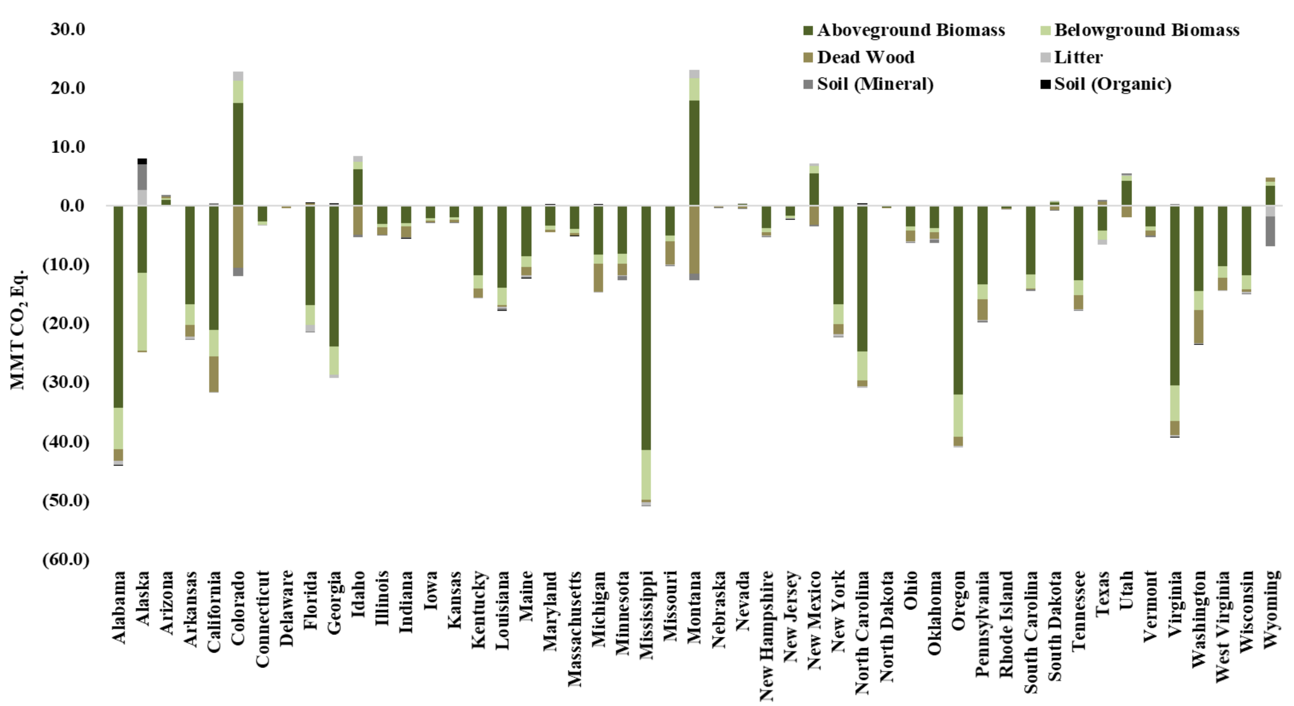


Figure 4-3a Net Annual Forest Carbon Stock Change by State and Carbon Pool, 2018
(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

occurred regularly throughout U.S. history (Caspersen et al. 2000). Overall, forest land area has remained relatively stable over the last several decades. Recent analyses suggest that net carbon losses from forest land conversion exceeded gains from afforestation and reforestation (Domke et al. 2020).

Over the 20-year conversion period used in the Land Converted to Forest Land category, the conversion of cropland to forest land resulted in the largest source of carbon transfer, accounting for approximately 40 percent of the uptake annually. Estimated carbon sequestration has remained relatively stable over the time series across all conversion categories (see Table 4-9). The net flux of carbon from all forest pool stock changes related to conversion in 2018 was -110.6 MMT CO_2 Eq. (Table 4-9).

Mineral soil C stocks increased slightly over the time series for Land Converted to Forest Land. The small gains are associated with Cropland Converted to Forest Land, Settlements Converted to Forest Land, and Other Land Converted to Forest Land. Much of this conversion is from soils that were more intensively used under annual crop production or settlement management, or are conversions from other land, which has little to no soil C. In contrast, Grassland Converted to Forest Land leads to a loss of soil C across the time series, which negates some of the gain in soil C with the other land use conversions. Managed pasture to Forest Land is the most common conversion. This leads to a loss of soil C because pastures are mostly improved in the United States with fertilization or irrigation, which enhances C input to soils relative to typical forest management activities. Table 4-9 summarizes carbon gain associated with land conversions to forest land over the time series, 1990–2018 by ecosystem carbon pool.

4.5 Methods

Estimates of forest ecosystem carbon in this chapter were obtained using inventory data to produce a series of successive carbon stock estimates for each individual State (EPA 2020, Domke et al. 2020). The USDA Forest Service's Forest Inventory and Analysis (FIA) Program conducts an annual inventory in each State each year with remeasurements of permanent sample plots every 5 to 10 years, depending on the State (USDA FS 2020b). The FIA Program defines the extent of forest land within each State (USDA FS 2020a, c), and limited adjustments on what to include in the greenhouse gas inventory to reflect UNFCCC reporting guidelines. Specifically, some of the forest area of Alaska is identified as unmanaged and excluded from these estimates (Ogle et al. 2018, Map 4-1). In addition, some stands of the woodland forest type groups are also excluded because they are on sites unlikely to support trees meeting the minimum height defined for "forest" (Coulston et al. 2016, Ogle et al. 2018, Nelson et al. 2020).

Current forest inventory data for the United States are available from the FIA Database (FIADB) version 8.0 (USDA FS 2020c). All FIADB data used in this report were obtained from the FIADB in July 2019 and are described in EPA (2020). The inventory-based methodologies for estimating forest C stocks are based on a combination of approaches (EPA 2020) and are consistent with the IPCC (2006) stock-difference (used for the conterminous United States) and gain-loss (used for Alaska) methods. Estimates of ecosystem C are based on data from the network of annual national forest inventory (NFI) plots established and measured by the FIA program within the USDA Forest Service;

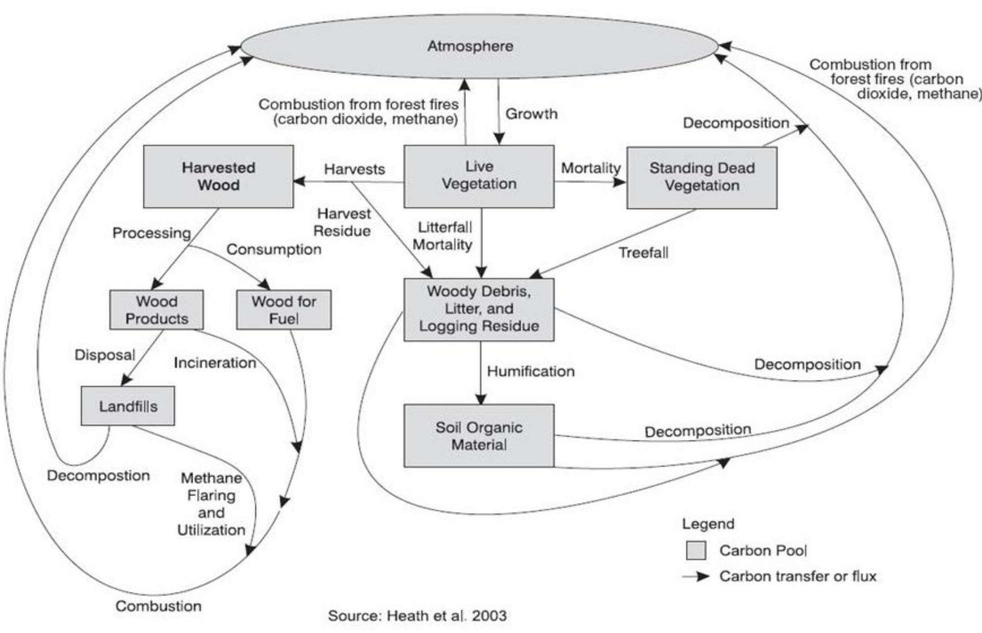


Figure 4-3b Summary Diagram of Forest Carbon Pools and Carbon Transfer Among Pools

Table 4-9: Net CO_2 Flux From C Stock Changes in Land Converted to Forest Land by Land-Use Change Category (MMT CO_2 Eq.)

Land Use Conversion	1990	1995	2000	2005	2010	2015	2018
Cropland Converted to Forest Land	(45.9)	(45.9)	(46.0)	(46.1)	(46.2)	(46.3)	(46.3)
Aboveground Biomass	(26.1)	(26.2)	(26.2)	(26.3)	(26.4)	(26.4)	(26.4)
Belowground Biomass	(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.2)	(5.2)
Dead Wood	(5.9)	(5.9)	(6.0)	(6.0)	(6.0)	(6.0)	(6.0)
Litter	(8.4)	(8.4)	(8.5)	(8.5)	(8.5)	(8.5)	(8.5)
Mineral Soil	(0.3)	(0.3)	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)
Grassland Converted to Forest Land	(9.8)	(9.7)	(9.7)	(9.6)	(9.6)	(9.6)	(9.7)
Aboveground Biomass	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)
Belowground Biomass	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)
Dead Wood	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)
Litter	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)
Mineral Soil	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Other Land Converted to Forest Land	(14.3)	(14.5)	(14.6)	(14.8)	(14.9)	(14.9)	(14.9)
Aboveground Biomass	(6.3)	(6.3)	(6.3)	(6.3)	(6.3)	(6.3)	(6.3)
Belowground Biomass	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)
Dead Wood	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
Litter	(4.1)	(4.2)	(4.2)	(4.2)	(4.2)	(4.2)	(4.2)
Mineral Soil	(0.6)	(0.8)	(0.9)	(1.1)	(1.1)	(1.1)	(1.1)
Settlements Converted to Forest Land	(38.6)	(38.6)	(38.7)	(38.7)	(38.8)	(38.9)	(38.9)
Aboveground Biomass	(23.2)	(23.2)	(23.3)	(23.3)	(23.3)	(23.4)	(23.4)
Belowground Biomass	(4.4)	(4.4)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)
Dead Wood	(4.6)	(4.6)	(4.6)	(4.6)	(4.6)	(4.6)	(4.6)
Litter	(6.3)	(6.3)	(6.4)	(6.4)	(6.4)	(6.4)	(6.4)
Mineral Soil	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)
Wetlands Converted to Forest Land	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)
Aboveground Biomass	(0.4)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Belowground Biomass	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Dead Wood	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Litter	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Mineral Soil	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Aboveground Biomass Flux	(60.6)	(60.6)	(60.8)	(60.9)	(61.0)	(61.0)	(61.0)
Total Belowground Biomass Flux	(11.8)	(11.8)	(11.8)	(11.9)	(11.9)	(11.9)	(11.9)
Total Dead Wood Flux	(13.3)	(13.4)	(13.4)	(13.4)	(13.4)	(13.4)	(13.4)
Total Litter Flux	(22.9)	(23.0)	(23.0)	(23.0)	(23.1)	(23.1)	(23.1)
Total SOC (mineral) Flux	(0.8)	(0.9)	(0.9)	(1.1)	(1.1)	(1.1)	(1.1)
Total Flux	(109.4)	(109.7)	(109.9)	(110.2)	(110.4)	(110.6)	(110.6)

either direct measurements or variables from the NFI are the basis for estimating metric tons of C per hectare in forest ecosystem C pools (i.e., aboveground and belowground biomass, dead wood, litter, and soil carbon). For the conterminous United States, plot-level estimates are used to inform land area (by use) and stand age transition matrices across time which can be summed annually for an estimate of forest C stock change for Forest Land Remaining Forest Land and Land Converted to Forest Land. A general description of the land use and stand age transition matrices that are informed by the annual NFI of the United States and were used in the estimation framework to compile estimates for the conterminous United States in this Inventory are described in Coulston et al. (2016). The annual NFI data in the conterminous United States allows for empirical estimation of net change in forest ecosystem carbon stocks within the estimation framework. In contrast, Wyoming and western Oklahoma have no remeasurement data so theoretical age transition matrices were developed (EPA 2020).

The incorporation of all managed forest land in Alaska was facilitated by an analysis to determine the managed land base in Alaska (Ogle et al. 2018), the expansion of the NFI into interior Alaska beginning in 2014, and a myriad of publicly available data products that provided information necessary for prediction of C stocks and fluxes on plots that have yet to be measured as part of the NFI.

4.5.1 Live Trees

Live tree carbon pools include aboveground and belowground (coarse root) biomass of live trees with a diameter at breast height (dbh) of at least 2.54 cm at 1.37 m above the forest floor. Separate estimates were made for aboveground and belowground biomass components. When inventory plots included data on individual trees, tree carbon was estimated using approaches defined by Woodall et al. (2011), which is also known as the component ratio method (CRM) and is a function of volume, species, and diameter. An additional component of foliage, which was not explicitly included in Woodall et al. (2011), was added to each tree following the CRM method and component proportions.

4.5.2 Understory Vegetation

Understory vegetation is defined as all biomass of undergrowth plants in a forest, including woody shrubs and trees less than 2.54 cm dbh. We assumed that 10 percent of understory carbon mass is belowground. This general root-to-shoot ratio (0.11) is near the lower range of temperate forest values provided in Penman et al. (2003) and was selected based on two general assumptions: (1) ratios are likely to be lower for light-limited understory vegetation as compared with larger trees, and (2) a greater proportion of all root mass will be less than 2 mm diameter. See Annex 3.13 of EPA (2020) for calculation details.

4.5.3 Dead Organic Matter

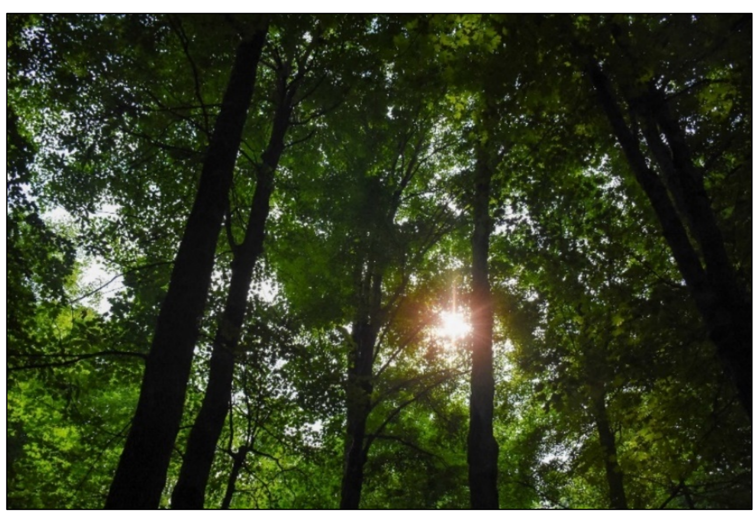
Dead organic matter was calculated as three separate pools: standing dead trees, down dead wood, and litter. Sample data or models were used to estimate carbon stocks. The standing-dead-tree carbon pools include aboveground and belowground (coarse root) mass and include dead trees of at least 12.7 cm dbh. Estimates followed the basic method applied to live trees (Woodall et al. 2011) with additional modifications to account for decay and structural loss (Domke et al. 2011, Harmon et al. 2011). Downed dead wood is defined as pieces of dead wood greater than 7.5 cm diameter, at transect intersection, which are not attached to live or standing dead trees. This includes stumps and roots of harvested trees. Downed-dead-wood estimates were a two-step calculation process detailed in Annex 3.13 of EPA (2020). Initial estimates based on live-tree carbon were modified according to measurements of a limited subset of FIA plots for downed dead wood (Domke et al. 2013, Woodall and Monleon 2008, Woodall et al. 2013). To facilitate the downscaling of downed-dead-wood carbon estimates from the State-wide population estimates to individual plots, downed-dead-wood models specific to regions and forest types within each region were used. Litter carbon is the pool of organic carbon (also known as duff, humus, and fine woody debris) above the mineral soil and includes woody fragments with diameters of up to 7.5 cm. Estimates are based on a model developed around measurements of a subset of FIA plots (Domke et al. 2016).

4.5.4 Soil Organic Carbon

Soil organic carbon (SOC) includes all organic material in soil to a depth of 1 meter but excludes the coarse roots of the biomass or dead wood pools. The modeling framework developed to predict SOC for this report was built around strategic-level forest and soil inventory information and auxiliary variables available for all FIA plots in the United States (Domke et al. 2017, EPA 2020).

4.5.5 Harvested Wood Products

Calculations for carbon in HWP are separate from the ecosystem estimates because the underlying datasets and methods are compiled separately. These methods are based on IPCC (2006) guidance for estimating HWP carbon (Skog 2008). IPCC (2006) guidance



provides methods that estimate HWP contribution using one of several different accounting approaches: production, stock change, and atmospheric flow, as well as a default method that assumes there is no change in HWP carbon stocks (see Annex 3.13 of EPA 2020 for more details about each approach). The U.S. GHG Inventory used the production accounting approach to report HWP contribution. Under the production approach, carbon in exported wood was estimated as if it remained in the United States, and carbon in imported wood was not included in inventory estimates. Annual estimates of change were calculated by tracking the additions to and removals from the pool of products held in end uses (i.e., products in use such as housing or publications) and the pool of products held in solid waste disposal sites.

4.6 Major Changes Compared to Previous Inventories

The estimates provided in Tables 4-1 and 4-2 reflect substantial incremental improvements in methods, models, and data between EPA (2015) and EPA (2020) in terms of net stock change since 1990. New annual inventory data for most States and adjustments to the identification of land area classified as forests included in the inventories have affected stock totals and changes as well as facilitated the separation of forest land remaining forest land and land converted to forest land. In addition, major changes in carbon conversion factors as applied to live and standing dead trees as well as the down dead wood, litter, and soil pools affected estimates as each update was implemented. When reviewing estimates provided for the 1990 to present interval, it is important to note that data updates and methodological changes can affect stock and stock change estimates throughout the interval, as can be seen when comparing Tables 4-1 and 4-2 with past versions of the same in USDA or EPA reports. See the methods (above) for general descriptions of new approaches and compare EPA 2015 and 2020 for additional details and references related to changes in the methods.

4.7 Uncertainty

The uncertainty analyses for total net flux of forest carbon (see Table 4-1) are consistent with the IPCC-recommended Tier 1 methodology (IPCC 2006). Specifically, they are considered approach 1 (propagation of error [Section 3.2.3.1]) (IPCC 2006). To better understand the effects of covariance, the contributions of sampling error and modeling error were parsed out. In addition, separate analyses were produced for forest ecosystem and HWP flux.

Estimates of forest carbon stocks in the United States are based on carbon estimates assigned to each of several thousand inventory plots from a regular grid. Uncertainty in these estimates and uncertainty associated with change estimates arise from many sources including sampling error and modeling error. Here we focus on these two types of error but acknowledge several other sources of error are present in the overall stock and stock change estimates. In terms of sampling-based uncertainty, design-based estimators described by Bechtold and Patterson (2005) were used to quantify the variance of carbon stock estimates. These calculations follow Bechtold and Patterson (2005).

Numerous assumptions were adopted for creation of the forest ecosystem uncertainty estimates. Potential pool error correlations were ignored. Given the magnitude of the mean squared error (MSE) for soil, including correlation among pool error would not appreciably change the modeling error contribution. Modeling error correlation between time 1 and time 2 was assumed to be 1. Because the MSE was fixed over time we assumed a linear relationship dependent on either the measurements at two points in time or an interpolation of measurements to arrive at annual flux estimates. Error associated with interpolation to arrive at annual flux is not included.

Uncertainty about net carbon flux in HWP is based on Skog et al. (2004) and Skog (2008). Estimates of the HWP variables and HWP contribution under the production approach are subject to many sources of uncertainty. The uncertainty estimates for HWP resulted from our evaluation of the effect of uncertainty in 13 sources, including production and trade data and parameters used to make the estimate. Uncertain data and parameters include: (a) data on production and trade and factors to convert them to carbon, (b) the census-based estimate of carbon in housing in 2001, (c) the EPA estimate of wood and paper discarded to solid waste disposal sites (SWDS) for 1990 to 2000, (d) the limits on decay of wood and paper in SWDS, (e) the decay rate (half-life) of wood and paper in SWDS, (f) the proportion of products produced in the United States made with wood harvested in the United States, and (g) the rate of storage of wood and paper carbon in other countries that came from U.S. harvest, compared to storage in the United States.

4.8 Planned Improvements

Development of improved methods and models as well as monitoring/reporting techniques is a continuous process that occurs as part of regular reporting for the national inventory. Planned improvements can be broadly assigned to the following categories: development of a robust estimation and reporting system, individual carbon pool estimation, coordination with other land-use categories, and annual inventory data incorporation.

While this Inventory submission includes C change by forest land remaining forest land and land converted to forest land and C stock changes for all IPCC pools in these two categories, there are many improvements that are still necessary. The estimation approach used for the continental United States in the current Inventory for the forest land category operates at the State scale, whereas previously the Western United States and southeast and southcentral coastal Alaska operated at a regional scale. While this is an improvement over previous Inventories and led to improved estimation and separation of land-use categories in the current Inventory, research is underway to leverage all FIA data and auxiliary information (i.e., remotely sensed information) to operate at finer spatial and temporal scales. The transparency and repeatability of estimation and reporting systems will be improved through the dissemination of open-source code (e.g., R programming language) in concert with the public availability of the annual NFI (USDA Forest Service 2020c). Also, several FIA database processes are being institutionalized to increase efficiency and QA/QC in reporting and further improve transparency, completeness, consistency, accuracy, and availability of data used in reporting. Finally, a combination of approaches was used to estimate uncertainty associated with C stock changes in the forest land remaining forest land category in this report. There is research underway investigating more robust approaches to total uncertainty (Clough et al. 2016), which will be considered in future Inventory reports.

The modeling framework used to estimate downed dead wood within the dead wood C pool is being updated, similar to previous updates to the litter (Domke et al. 2016) and soil C pools (Domke et al. 2017). Finally, components of other pools, such as C in belowground biomass (Russell et al. 2015) and understory vegetation (Russell et al. 2014; Johnson et al. 2017), are being explored but may require additional investment in field inventories before improvements can be realized within the Inventory report.

The foundation of forest C estimation and reporting is the annual NFI. The ongoing annual surveys by the FIA program are expected to improve the accuracy and precision of forest C estimates as new State surveys become available (USDA Forest Service 2020b). With the exception of Wyoming and western Oklahoma, all other States in the continental United States now have sufficient annual NFI data to consistently estimate C stocks and stock changes for the future using the State-level compilation system. The FIA program continues to install permanent plots in Alaska as part of the operational NFI and as more plots are added to the NFI they will be used to improve estimates for all managed forest land in Alaska. The methods used to include all managed forest land in Alaska will be used in future improvements to estimates in Hawaii and U.S. Territories as forest C data become available (only a small number of plots from Hawaii are currently available from the annualized sampling design). To that end, research is underway to incorporate all NFI information (both annual and periodic data) and the dense time series of remotely sensed data in multiple inferential frameworks for estimating greenhouse gas emissions and removals, as well as change detection and attribution across the entire reporting period and all managed forest land in the United States.

In addition to fully inventorying all managed forest land in the United States, the more intensive sampling of fine woody debris, litter, and SOC on a subset of FIA plots continues and will substantially improve resolution of C pools (i.e., greater sample intensity) as this information becomes available (Woodall et al. 2011). Increased sample intensity of some C pools and using annualized sampling data as it becomes available for those States currently not reporting are planned for future submissions. The NFI sampling frame extends beyond the forest land-use category (e.g., woodlands, which fall into the grasslands land-use category, and urban areas, which fall into the settlements land-use category) with inventory-relevant information for trees outside of forest land. These data will be utilized as they become available in the NFI.

4.9 References

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4.10 Appendix C

Appendix Table C-1. State-Level Estimates of Forest Land Area (1,000 ha) and Carbon Stock Changes (MMT CO_2 Eq.) by Pool for 2018

State	Forest area	Aboveground Biomass	Belowground Biomass	Dead Wood	Litter	Soil (Mineral)	Soil (Organic)
Alabama	9,309	(34.3)	(7.0)	(1.9)	(0.7)	0.2	(0.0)
Alaska	28,729	(11.3)	(13.3)	(0.2)	2.7	4.4	1.0
Arizona	4,435	1.1	0.3	0.2	0.1	0.2	
Arkansas	7,633	(16.7)	(3.4)	(2.0)	(0.4)	(0.2)	
California	12,137	(21.0)	(4.6)	(6.0)	(0.1)	0.5	0.0
Colorado	7,366	17.5	3.8	(10.6)	1.6	(1.3)	
Connecticut	724	(2.6)	(0.5)	(0.0)	(0.1)	0.2	0.0
Delaware	141	(0.1)	(0.0)	(0.2)	0.0	0.0	0.0
Florida	6,713	(16.8)	(3.4)	0.6	(1.1)	(0.1)	0.1
Georgia	9,834	(23.9)	(4.7)	0.1	(0.6)	0.3	0.0
Idaho	8,738	6.2	1.4	(4.8)	1.0	(0.4)	
Illinois	2,008	(3.0)	(0.6)	(1.3)	(0.1)	(0.1)	0.0
Indiana	1,958	(3.0)	(0.5)	(1.8)	(0.0)	(0.1)	(0.0)
Iowa	1,153	(2.0)	(0.4)	(0.3)	(0.1)	(0.0)	
Kansas	980	(2.0)	(0.4)	(0.5)	(0.0)	(0.0)	
Kentucky	4,952	(11.7)	(2.2)	(1.6)	(0.1)	0.2	
Louisiana	6,127	(13.9)	(2.9)	(0.3)	(0.2)	(0.3)	(0.0)
Maine	7,104	(8.5)	(1.8)	(1.4)	(0.3)	(0.1)	(0.0)
Maryland	948	(3.4)	(0.6)	(0.5)	0.0	0.2	0.0
Massachusetts	1,210	(3.8)	(0.7)	(0.4)	(0.1)	0.1	(0.0)
Michigan	8,161	(8.2)	(1.6)	(4.7)	(0.2)	0.2	0.0
Minnesota	7,081	(8.1)	(1.6)	(2.1)	(0.1)	(0.7)	0.1
Mississippi	7,776	(41.4)	(8.5)	(0.4)	(0.6)	(0.2)	0.0
Missouri	6,174	(5.0)	(0.9)	(3.9)	(0.1)	(0.2)	
Montana	10,018	17.9	3.9	(11.5)	1.4	(1.2)	
Nebraska	562	0.0	0.0	(0.2)	0.0	(0.1)	
Nevada	2,624	0.3	0.1	(0.3)	0.0	(0.1)	
New Hampshire	1,901	(3.7)	(0.7)	(0.5)	(0.1)	(0.1)	
New Jersey	796	(1.7)	(0.3)	(0.1)	(0.0)	(0.1)	(0.0)
New Mexico	5,869	5.6	1.3	(3.2)	0.4	(0.3)	
New York	7,492	(16.7)	(3.2)	(1.8)	(0.4)	(0.1)	0.0
North Carolina	7,554	(24.7)	(4.9)	(1.1)	(0.2)	0.4	0.1
North Dakota	308	(0.2)	(0.0)	(0.0)	0.0	0.2	
Ohio	3,189	(3.5)	(0.6)	(1.8)	(0.1)	(0.1)	
Oklahoma	4,777	(3.7)	(0.8)	(1.0)	(0.2)	(0.5)	
Oregon	11,856	(32.0)	(7.1)	(1.6)	(0.4)	0.1	
Pennsylvania	6,718	(13.3)	(2.5)	(3.5)	(0.2)	(0.2)	
Rhode Island	148	(0.3)	(0.1)	(0.1)	(0.0)	0.1	0.0
South Carolina	5,159	(11.6)	(2.3)	(0.2)	(0.1)	(0.3)	0.0
South Dakota	773	0.6	0.1	(0.6)	0.1	(0.0)	
Tennessee	5,595	(12.6)	(2.4)	(2.4)	(0.1)	(0.1)	
Texas	15,489	(4.2)	(1.4)	0.8	(0.8)	0.3	
Utah	4,560	4.2	0.8	(1.9)	0.2	0.3	
Vermont	1,792	(3.5)	(0.7)	(0.8)	(0.0)	(0.2)	0.0
Virginia	6,485	(30.5)	(6.0)	(2.4)	(0.3)	0.3	(0.0)
Washington	9,005	(14.4)	(3.2)	(5.6)	(0.2)	0.2	(0.0)
West Virginia	4,861	(10.3)	(1.9)	(2.2)	(0.1)	0.0	
Wisconsin	6,835	(11.8)	(2.3)	(0.4)	(0.4)	(0.0)	0.1
Wyoming	4,029	3.4	0.8	0.7	(1.7)	(5.1)	

Chapter 5: Energy Use in Agriculture

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5.1 Summary of Greenhouse Gas Emissions From On-Farm Energy Use in Agriculture

Approximately 0.96 quadrillion BTU of direct energy were used in agricultural production in 2018, resulting in almost 79 MMT of CO_2 emissions (Table 5-1). The total energy consumption for all sectors in the United States, including agriculture, resulted in 5,249.3 MMT of CO_2 emissions (EPA 2020a). Production agriculture contributed approximately 1.5 percent of those total emissions. Within production agriculture, diesel fuel accounted for about 48 percent of CO_2 emissions and electricity contributed close to 31 percent of CO_2 emissions. Gasoline consumption accounted for 9.9 percent of CO_2 emissions, while liquefied petroleum (LP) gas and natural gas accounted for 6.6 percent and 4.3. percent respectively.

5.2 Spatial and Temporal Trends in Greenhouse Gas Emissions From On-Farm Energy Use in Agriculture

The highest total emissions from agricultural energy use in 2018 were in California and Texas followed by States in the Corn Belt, Northern and Southern Plains and Lake States (regions are defined in Table 5-2). The top six States were Nebraska, Iowa, Minnesota and Illinois, while the lowest six were Rhode Island, Alaska, New Hampshire, Hawaii, Massachusetts, and Connecticut. There is a strong correlation between production and energy use/emissions of over 99 percent. Generally, the States with the most agricultural production use the most energy and therefore have the highest CO_2 emissions from agricultural production (Map 5-1). However, emissions also vary by the types of energy used for farm production in each region. For example, even though California had the highest total CO_2 emissions, its emissions per unit of energy used were below the U.S. average due to reliance on renewable energy and possible production efficiencies. Arizona, Idaho, Nevada, and Utah from the Mountain region, and Oregon from the Pacific region (regions are defined in Table 5-2) are the five States with the lowest CO_2 emissions per unit of energy used, and are leading States in renewable energy (Map 5-1).

Agricultural energy use and the resulting CO_2 emissions grew throughout the 1960s and 1970s, peaking in the late 1970s (Figure 5-1). High energy prices, stemming from the oil crises of the 1970s and early 1980s, drove farmers to be more energy efficient, resulting in a decline in total energy use and CO_2 emissions throughout most of the 1980s (Miranowski 2005). This decline is attributed to switching from gasoline-powered to more fuel-efficient diesel-powered engines, adopting energy-conserving tillage practices, shifting to larger multifunction machines, and adopting energy-saving methods for crop drying and irrigation (Uri and Day 1991; Sandretto and Payne

Table 5-1 Energy Use and Carbon Dioxide Emissions by Fuel Source on U.S. Farms, 2018

Fuels	Energy consumed	Carbon content	Fraction oxidized	CO_2 emissions
	QBTU	*MMT C/QBTU*		*MMT CO_2 eq.*
Diesel	0.51	20.17	1	37.96
Gasoline	0.11	19.46	1	7.80
LP[1] gas	0.08	16.83	1	5.16
Natural gas	0.06	14.43	1	3.41
Electricity	0.19	**	**	24.38
Total	0.96			78.72

Note: QBTU is quadrillion British thermal units. MMT C/QBTU is million metric tons carbon per quadrillion British thermal units. MMT CO_2 eq. is million metric tons carbon dioxide equivalent.
[1] LP gas = liquefied petroleum gas
** Varies dependent on fuel source used to generate electricity and heat rate of power generating plants.

Table 5-2 Definition of Regions

Region	States of Region	Region	States of Region	Region	States of Region
Corn Belt	Illinois	**Pacific**	California	**Southeast**	Alabama
	Indiana		Oregon		Florida
	Iowa		Washington		Georgia
	Missouri	**Southern Plains**	Oklahoma		South Carolina
	Ohio		Texas	**Northeast**	Connecticut
Mountain	Arizona	**Lake States**	Michigan		Delaware
	Colorado		Minnesota		Maine
	Idaho		Wisconsin		Maryland
	Montana	**Appalachian**	Kentucky		Massachusetts
	Nevada		North Carolina		New Hampshire
	New Mexico		Tennessee		New Jersey
	Utah		Virginia		New York
	Wyoming		West Virginia		Pennsylvania
Northern Plains	Kansas	**Delta States**	Arkansas		Rhode Island
	Nebraska		Louisiana		Vermont
	North Dakota		Mississippi	**Other**	Alaska
	South Dakota				Hawaii

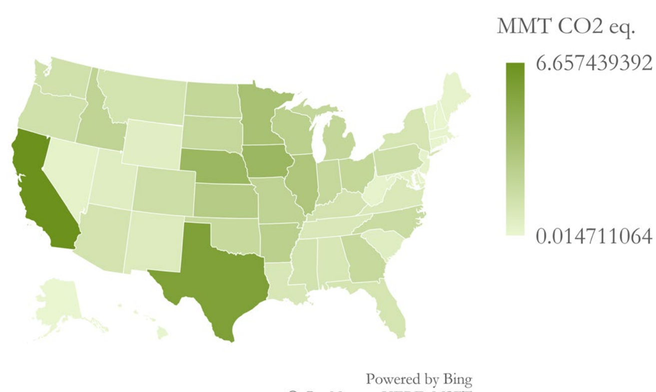
2006; Lin et al. 1995). Furthermore, policies such as the Energy Policy and Conservation Act of 1975 resulted in greater average fuel economy standards, and both gasoline- and diesel-powered equipment became increasingly energy efficient throughout the 1980s and 1990s. Declines in farm energy use leveled off in the late 1980s as energy prices dropped (Figure 5-1). Total energy use increased throughout most of the 1990s but, since 2000, yearly changes in total energy use have been annually variable. However, energy productivity (i.e., output per unit of energy input) has increased significantly over that time, due to higher crop yields and more energy efficient input use. The spikes in diesel and gasoline use in 2009 reflect a spike in U.S. corn and soybean production that year. Diesel use increased again as production increased after 2013 and the spike in diesel use of 2016 reflected record corn production and soybean exports.

5.3 Sources of Greenhouse Gas Emissions From Energy Use on Agricultural Operations

Agricultural operations—including crop and livestock farms, dairies, nurseries, orchards, and greenhouses—require a variety of energy sources. On-farm energy use varies by commodity produced, size of operation, and geographic location. On-farm energy use also varies over time, depending on weather conditions, changes in energy prices, and changes in total annual crop and livestock production. For example, estimated diesel use spiked in 2009 and 2016 with increased corn and soybean production (Figure 5-1). The demand for diesel fuel in 2009 and 2016 was also boosted by low bulk diesel prices, which fell to their lowest levels since 2005, dropping to below $2.00 per gallon compared to an average of $2.82 per gallon between 2008 and 2018 (USDA/NASS 1990–2018). In 2012, when corn production was down because of a drought, the energy-use estimates for diesel fuel, LP gas, and natural gas all moved downward (USDA NASS 2014). Energy used on farms is typically categorized as direct or indirect energy (Miranowski 2005). Direct energy is energy used on the farm, whereas indirect energy is the energy used to produce energy-intensive farm inputs, such as commercial fertilizers.

Liquid fuel is the most versatile form of direct energy used on farms because it can be used in vehicles and stationary equipment. Crop production uses large amounts of diesel fuel, gasoline, and LP gas for field operations. Most large farms use diesel-fueled vehicles for tilling, planting, cultivating, disking, harvesting, and applying fertilizers and pesticides. Gasoline is used for small trucks and older harvesting equipment. Smaller farms are more likely to use gasoline-powered equipment. As farms have grown larger over time, overall gasoline consumption has declined (Figure 5-1).

Farmers use a significant amount of energy to dry crops such as grain, tobacco, and peanuts. LP gas, electricity, diesel fuel, or natural gas can be used for crop drying. Annual rainfall can have a significant effect on the amount of energy used to dry crops from year to year. Above average rainfall, especially just prior to harvest time, increases the moisture level of



Map 5-1 CO_2 Emissions From Energy Use in Agriculture, by State, 2018
(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)

grain, and more energy may be required to dry the grain to meet quality standards.

Weather can also affect the energy used in livestock facilities, greenhouses, and other farm buildings. Natural gas and electricity are commonly used for controlling indoor temperatures. The highest natural gas consumption since 1990 was in 2014 which coincided with a record cold winter (NOAA, 2020). A significant amount of electricity is also used for lighting, air circulation, and powering electric motors with various functions. For example, dairies rely heavily on electricity to power milking machines. The applications of electric-powered farm equipment have increased over time, contributing to higher on-farm electricity use.

There were almost 56 million irrigated acres in 2018, up by about 620,000 from 2013. While some irrigation systems are gravity-flow systems that require relatively little energy for water distribution, irrigation systems that use pumps are energy intensive. Based on the 2018 USDA Farm and Ranch Irrigation Survey, about 50 million acres of U.S. farmland were irrigated with pumps powered by liquid fuels, natural gas, LP gas, and electricity, costing a total of $2.42 billion, $0.25 billion less than in 2013 (USDA/NASS 2018). Electricity was the principal power source for these pumps, costing about $1.89 billion to irrigate about 34 million acres. Diesel fuel was used to power pumps on slightly over 11 million acres, costing $339 million, and natural gas was used on about 3.8 million acres, costing around $167 million (USDA/NASS 2018). LP gas and butane powered the irrigation of about 950,000 acres with a cost of $24 million and the remaining 103,500 irrigation acreage was powered by gasoline at a cost of $3.7 million. Near 150,000 acres were irrigated with solar and other pumps without direct energy expenses, an almost tenfold increase since 2003 when around 16,000 acres were similarly irrigated (USDA NASS 2018).

Indirect energy is used off the farm to manufacture farm inputs that are ultimately consumed on the farm. Some farm inputs such as fertilizers and pesticides are produced by energy-intensive industries. For example, commercial nitrogen fertilizer is made primarily from natural gas, and synthetic pesticides are made from a variety of chemicals. Although GHG emissions result from the energy consumption used in manufacturing agricultural inputs, these indirect emissions are not detailed in this inventory. For information on the GHG emissions associated with manufacturing commercial fertilizers, see *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2018* (EPA 2020a).

5.4 Methods for Estimating Carbon Dioxide Emissions From Energy Use in Agriculture

CO_2 emission estimates for energy use are constructed from fuel consumption data using standardized methods published in the U.S. GHG Inventory. Emission estimates for fuel use in agriculture are not specifically called out in the U.S. GHG Inventory; however, they are contained in the estimates of fuel consumption and emissions by sectors. The emissions estimates presented in this chapter were prepared separately from the U.S. GHG Inventory.

Estimates of CO_2 from agricultural operations are based on annual energy expense data from the Agricultural Resource Management Survey (ARMS) conducted by the National Agricultural Statistics Service (NASS) of the USDA. NASS collects information on farm production expenditures including expenditures on diesel fuel, gasoline, LP gas, natural gas, and electricity use on the farm with the annual Agricultural Resources Management Survey (ARMS). A USDA publication (USDA/NASS 2020) shows national totals as well as select States, and for ARMS production regions. State estimates are survey derived for 15 States (AK, CA, FL, GA, IA, IL, IN, KS, MN, MO, NC, NE, TX, WA, WI) and model derived for the remaining States using data and methods developed by ERS. NASS also collects data on price per gallon paid by farmers for gasoline, diesel, and LP gas (USDA NASS 2005–2018). While these data have not been published since 2014 and are instead replaced with an index for prices paid relative to

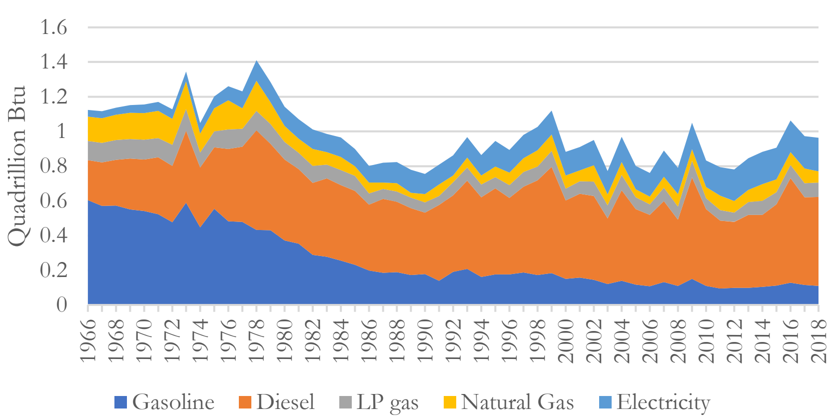


Figure 5-1 Energy Use in Agriculture, by Source, 1965–2018
(BTU is British thermal unit)

2011, they continue to be used in the estimation. Energy expenditures are divided by fuel prices to approximate gallons of fuel consumed, allowing fuel consumption to be estimated at the State and national levels. Gallons of gasoline, diesel, and LP gas are then converted to BTU based on the heating value of each of the fuels (Figure 5-1). Farm consumption estimates for electricity and natural gas are also approximated by dividing prices into expenditures. Because the prices farmers pay for electricity and natural gas are not collected by NASS, we use data from the Energy Information Administration (EIA), which reports average prices by State (EIA 2020a; EIA 2020b).

Following the method outlined in Annex 2 of the U.S. GHG Inventory, consumption of diesel fuel, gasoline, LP gas, and natural gas used on the farm were converted to CO_2 emissions using the coefficients for carbon content of fuels and fraction of carbon oxidized during combustion (Table 5-1). These carbon content coefficients were derived by EIA and are similar to those published by the Intergovernmental Panel on Climate Change (IPCC). For each fuel type, fuel consumption in units of quadrillion BTU at the national and State level were multiplied by the respective carbon content coefficient to estimate the million metric tons (MMT) of carbon contained in the fuel consumed (Table 5.1 and Map 5.1). This value is sometimes referred to as "potential emissions" because it represents the maximum amount of carbon that could be released to the atmosphere if all carbon were oxidized (EPA 2020a). To convert from carbon content to CO_2, it was assumed that 100 percent of the carbon became oxidized.

A different approach was used to estimate emissions from electricity. Several fuel sources can be used to generate electricity; therefore, the mix of fuel sources can vary significantly by region. Some States for example rely more on coal for electricity generation, while other States use more natural gas to generate electricity. The CO_2 emission estimates from electricity generation in this chapter are calculated based on the national and State annual CO_2 total output emission rate (lb/MWh) available from EPA's Emissions & Generation Resource Integrated Database (eGRID) (EPA 2020b) which accounts for this variation. These output emission rates were multiplied by estimated electricity use in each State and the United States as a whole, to calculate the respective CO_2 emissions (Table 5-1 and Map 5-1). As reported above, electricity use is estimated from farm expenditure data collected by NASS. Price estimates for electricity published by EIA are divided into electricity expenditures to derive the kilowatt hours consumed on agricultural operations. For energy use in agriculture (Figure 5-1), the kilowatt hours of electricity used on the farm are converted to BTU, based on a standard conversion rate of 3,413 BTU per kilowatt hour.

5.5. Major Changes Compared to Previous Inventories

This report is the fifth edition of the U.S. Agriculture and Forestry Greenhouse Inventory, which estimates GHG emissions up to the year 2018. In comparison to previous editions the following changes have been applied: i) commercial electricity and natural gas prices are used instead of residential electricity prices; ii) Spatial trends are presented at the State level rather than the ARMS production regions level. The regions are still defined in Table 5-2 to ease comparison with previous publications; iii) the CO_2 emission estimates from electricity generation are calculated based on the national and State annual CO_2 total output emission rate (lb/MWh) available from EPA's Emissions & Generation Resource Integrated Database (eGRID) (EPA 2020b).

Figure 5-2 compares the 2018 results with the four previous study periods, 2013, 2008, 2005 and 2001. As discussed in Section 5.3, annual GHG emissions from energy use in the agricultural sector will vary with changes in crop and livestock production levels and with changes in annual weather conditions. Total emissions are highest in 2001, followed by 2018. (Figure 5-2). Changes in GHG emissions generally follow long-term energy trends, as shown in Figure 5-1. When a short-term fluctuation in GHG emissions occurred, it was likely related to a major weather event, energy prices, or other factors significantly affecting agricultural production.

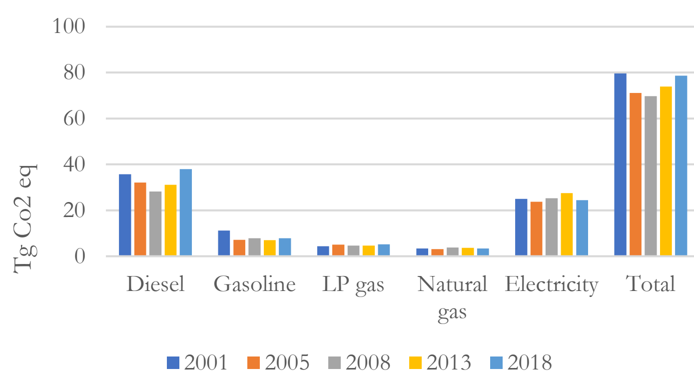


Figure 5-2 CO_2 Emissions From Energy Use in Agriculture, by Fuel Source, 2001, 2005, 2008, 2013, and 2018
(MMT CO2 eq. is million metric tons of carbon dioxide equivalent)

5.6 References

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