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6

# Land Use, Land-Use Change, and Forestry (LULUCF)

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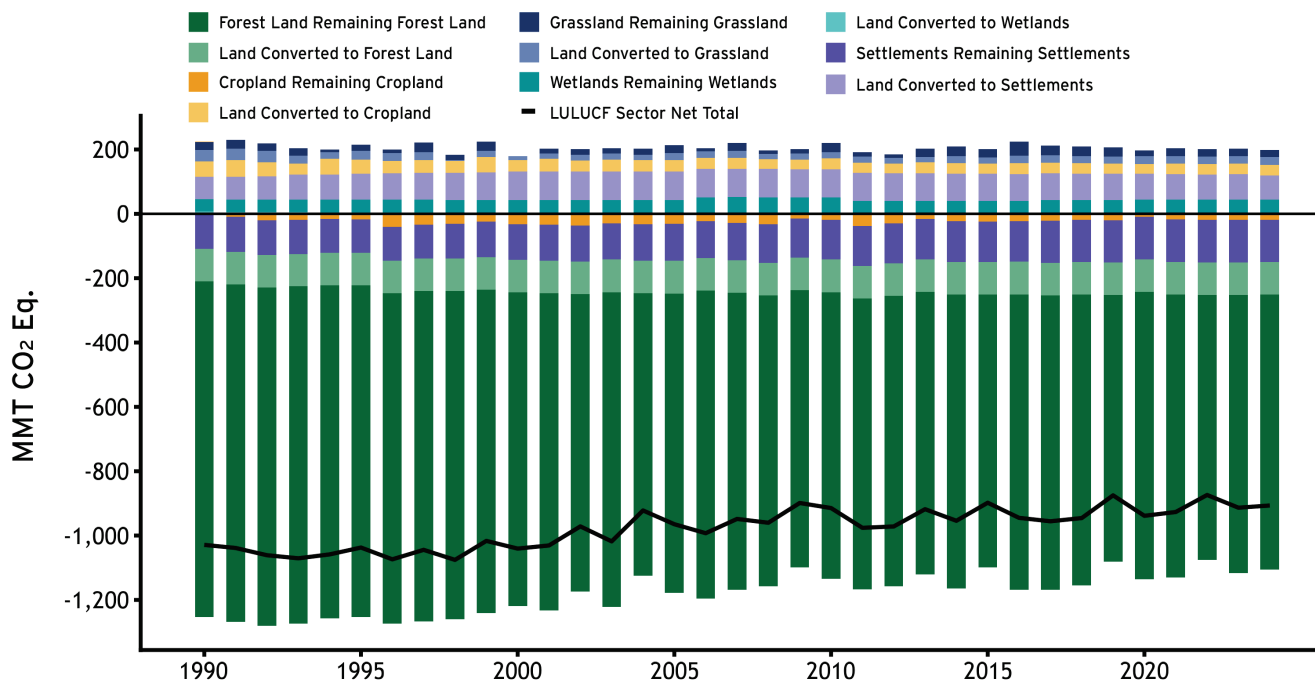
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# Chapter 6. Land Use, Land-Use Change, and Forestry

The land use, land-use change, and forestry (LULUCF) sector includes greenhouse gas (GHG) emissions and removals (referred to as a net flux) associated with changes within and conversions between the Intergovernmental Panel on Climate Change (IPCC) land-use categories, including forest land (including harvested wood products [HWP]), cropland, grassland, wetlands, settlements, and other land uses.

**Figure 6-1: Trends in Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry**



Note: Each category/bar includes estimates of annual net GHG fluxes, including non-CO<sub>2</sub> emissions and changes in ecosystem carbon stocks. The “LULUCF Sector Net Total” line reflects net total emissions and removals occurring across all land-use categories.

In 2024, the overall net flux from the LULUCF sector resulted in a removal<sup>1</sup> of 906.5 million metric tons of carbon dioxide equivalent (MMT CO<sub>2</sub> Eq.) (see Table 6-1 and Figure 6-1). This represents an offset equivalent of approximately 14.6 percent of total (i.e., gross) GHG emissions

<sup>1</sup> Carbon sequestration estimates are expressed as net values, reflecting the balance between annual carbon gains and losses within a given pool. When losses exceed gains, the carbon stock declines and the pool functions as a source resulting in net emissions, whereas when gains exceed losses, the carbon stock increases and the pool acts as a sink and results in net removals of CO<sub>2</sub> from the atmosphere.

in 2024, primarily from existing forests. The total net flux reflects an increase in carbon stocks (i.e., net carbon dioxide [CO<sub>2</sub>] removals) of 966.5 MMT CO<sub>2</sub> Eq. and emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) of 54.9 and 5.1 MMT CO<sub>2</sub> Eq., respectively, driven by carbon being sequestered in existing forest land (forest land remaining forest land), trees in urban areas, and lands being converted to forests (e.g., afforestation). Although forests have remained a net carbon sink over the time series, the rate in which existing forest lands are sequestering carbon is slowing, resulting in an 18 percent decline in the forest land remaining forest land sink (less annual carbon sequestration) since 1990 (see Figure 6-1).

Flooded land remaining flooded land was the largest source of non-CO<sub>2</sub> emissions from LULUCF in 2024, accounting for 79.6 percent of the LULUCF sector non-CO<sub>2</sub> emissions. Non-CO<sub>2</sub> emissions from forest fires were the second largest source of LULUCF sector emissions, accounting for 7.3 percent of LULUCF non-CO<sub>2</sub> emissions in 2024.

**Table 6-1: Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO<sub>2</sub> Eq.)**

Land-Use Category	1990	2005	2020	2021	2022	2023	2024
<b>Forest Land Remaining Forest Land</b>	<b>(1,043.1)</b>	<b>(930.9)</b>	<b>(892.9)</b>	<b>(879.0)</b>	<b>(822.9)</b>	<b>(864.9)</b>	<b>(854.8)</b>
Changes in Forest Carbon Stocks <sup>a</sup>	(1,049.0)	(949.0)	(919.3)	(903.7)	(839.1)	(871.3)	(859.7)
Non-CO <sub>2</sub> Emissions from Forest Fires <sup>b</sup>	5.8	17.6	26.0	24.3	15.7	6.0	4.4
N <sub>2</sub> O Emissions from Forest Soils <sup>b</sup>	0.1	0.4	0.4	0.4	0.4	0.4	0.4
Non-CO <sub>2</sub> Emissions from Drained Organic Soils <sup>b</sup>	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<b>Land Converted to Forest Land</b>	<b>(100.8)</b>	<b>(101.2)</b>	<b>(100.9)</b>	<b>(100.9)</b>	<b>(100.8)</b>	<b>(100.8)</b>	<b>(100.9)</b>
Changes in Forest Carbon Stocks	(100.8)	(101.2)	(100.9)	(100.9)	(100.8)	(100.8)	(100.9)
<b>Cropland Remaining Cropland</b>	<b>1.0</b>	<b>(31.0)</b>	<b>(9.6)</b>	<b>(17.7)</b>	<b>(18.6)</b>	<b>(18.1)</b>	<b>(18.0)</b>
Changes in Ecosystem Carbon Stocks <sup>c</sup>	1.0	(31.0)	(9.6)	(17.7)	(18.6)	(18.1)	(18.0)

*(continued)*

**Table 6-1: Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO<sub>2</sub> Eq.) (continued)**

Land-Use Category	1990	2005	2020	2021	2022	2023	2024
<b>Land Converted to Cropland</b>	<b>48.5</b>	<b>35.5</b>	<b>29.6</b>	<b>32.2</b>	<b>32.3</b>	<b>32.5</b>	<b>32.6</b>
Changes in all Ecosystem Carbon Stocks	48.5	35.5	29.6	32.2	32.3	32.5	32.6
<b>Grassland Remaining Grassland</b>	<b>24.2</b>	<b>24.5</b>	<b>17.0</b>	<b>24.7</b>	<b>23.2</b>	<b>23.2</b>	<b>22.9</b>
Changes in All Ecosystem Carbon Stocks	24.0	23.7	15.9	23.7	22.5	22.5	22.2
Non-CO <sub>2</sub> Emissions from Grassland Fires <sup>d</sup>	0.2	0.8	1.1	0.9	0.6	0.7	0.7
<b>Land Converted to Grassland</b>	<b>35.6</b>	<b>21.9</b>	<b>25.1</b>	<b>23.0</b>	<b>23.7</b>	<b>24.1</b>	<b>24.7</b>
Changes in all Ecosystem Carbon Stocks	35.6	21.9	25.1	23.0	23.7	24.1	24.7
<b>Wetlands Remaining Wetlands</b>	<b>38.5</b>	<b>40.9</b>	<b>44.0</b>	<b>43.9</b>	<b>44.0</b>	<b>43.9</b>	<b>44.0</b>
Changes in Organic Soil Carbon Stocks in Peatlands	1.1	1.1	0.6	0.5	0.6	0.5	0.6
Non-CO <sub>2</sub> Emissions from Peatlands Remaining Peatlands	+	+	+	+	+	+	+
Changes in Biomass, DOM, and Soil Carbon Stocks in Coastal Wetlands	(10.8)	(10.1)	(8.6)	(8.5)	(8.4)	(8.4)	(8.3)
CH <sub>4</sub> Emissions from Coastal Wetlands Remaining Coastal Wetlands	4.2	4.2	4.1	4.0	3.9	3.9	3.8

(continued)

**Table 6-1: Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO<sub>2</sub> Eq.) (continued)**

Land-Use Category	1990	2005	2020	2021	2022	2023	2024
N <sub>2</sub> O Emissions from Coastal Wetlands	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Remaining Coastal Wetlands							
CH <sub>4</sub> Emissions from Flooded Land	43.9	45.5	47.7	47.7	47.7	47.8	47.8
Remaining Flooded Land							
<b>Land Converted to Wetlands</b>	<b>6.7</b>	<b>1.9</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>
Changes in Biomass, DOM, and Soil Carbon Stocks in Land Converted to Coastal Wetlands	0.5	0.5	+	+	+	+	+
CH <sub>4</sub> Emissions from Land Converted to Coastal Wetlands	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Changes in Land Converted to Flooded Land	3.3	0.6	0.3	0.3	0.3	0.3	0.3
CH <sub>4</sub> Emissions from Land Converted to Flooded Land	2.7	0.5	0.2	0.2	0.2	0.2	0.2
<b>Settlements Remaining Settlements</b>	<b>(109.1)</b>	<b>(115.2)</b>	<b>(131.9)</b>	<b>(132.5)</b>	<b>(132.6)</b>	<b>(132.6)</b>	<b>(131.9)</b>
Changes in Organic Soil Carbon Stocks	9.9	10.1	15.1	15.4	15.8	16.3	16.7
Changes in Settlement Tree Carbon Stocks	(96.5)	(117.0)	(136.6)	(137.6)	(138.4)	(139.0)	(139.9)

(continued)

**Table 6-1: Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO<sub>2</sub> Eq.) (continued)**

Land-Use Category	1990	2005	2020	2021	2022	2023	2024
N <sub>2</sub> O Emissions from Settlement Soils <sup>e</sup>	2.1	3.1	2.3	2.3	2.3	2.3	2.3
Changes in Yard Trimming and Food Scrap Carbon Stocks in Landfills	(24.5)	(11.4)	(12.8)	(12.5)	(12.3)	(12.1)	(11.0)
<b>Land Converted to Settlements</b>	<b>69.5</b>	<b>89.0</b>	<b>80.3</b>	<b>78.8</b>	<b>77.3</b>	<b>78.4</b>	<b>74.1</b>
Changes in all Ecosystem Carbon Stocks	69.5	89.0	80.3	78.8	77.3	78.4	74.1
<b>LULUCF Emissions<sup>f</sup></b>	<b>59.4</b>	<b>72.6</b>	<b>82.2</b>	<b>80.3</b>	<b>71.3</b>	<b>61.7</b>	<b>60.0</b>
CH <sub>4</sub>	54.6	61.3	69.2	67.8	61.9	56.1	54.9
N <sub>2</sub> O	4.8	11.3	13.0	12.5	9.3	5.6	5.1
<b>LULUCF Carbon Stock Change<sup>g</sup></b>	<b>(1,088.3)</b>	<b>(1,037.3)</b>	<b>(1,020.7)</b>	<b>(1,007.0)</b>	<b>(945.1)</b>	<b>(975.0)</b>	<b>(966.5)</b>
<b>LULUCF Sector Net Total<sup>h</sup></b>	<b>(1,028.9)</b>	<b>(964.7)</b>	<b>(938.6)</b>	<b>(926.7)</b>	<b>(873.8)</b>	<b>(913.4)</b>	<b>(906.5)</b>

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

<sup>a</sup> Includes the net changes to carbon stocks stored in all forest ecosystem pools and harvested wood products.

<sup>b</sup> Estimates include emissions from both forest land remaining forest land and land converted to forest land.

<sup>c</sup> Estimates include the net changes to carbon stocks stored in all aboveground biomass, mineral soils and organic soils ecosystem pools.

<sup>d</sup> Estimates include CH<sub>4</sub> and N<sub>2</sub>O emissions from fires on both grassland remaining grassland and land converted to grassland.

<sup>e</sup> Estimates include N<sub>2</sub>O emissions from nitrogen fertilizer additions on both settlements remaining settlements and land converted to settlements.

<sup>f</sup> LULUCF emissions include the CH<sub>4</sub> and N<sub>2</sub>O emissions reported for peatlands remaining peatlands, forest fires, drained organic soils, grassland fires, and coastal wetlands remaining coastal wetlands; CH<sub>4</sub> emissions from land converted to coastal wetlands, flooded land remaining flooded land, and land converted to flooded land; and N<sub>2</sub>O emissions from forest soils and settlement soils.

<sup>g</sup> LULUCF carbon stock change includes any carbon stock gains and losses from all land use and land-use conversion categories.

<sup>h</sup> The LULUCF sector net total is the net sum of all LULUCF CH<sub>4</sub> and N<sub>2</sub>O emissions to the atmosphere plus LULUCF net carbon stock changes in units of MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.



Unless otherwise noted, all estimates in this chapter are provided in MMT CO<sub>2</sub> Eq. Consistent with GHG inventories from other countries, this *Greenhouse Gas Inventory and Analysis for the United States (GHGIA)* uses 100-year Global Warming Potential values from Table 8.A.1 in Appendix 8.A of the *IPCC Fifth Assessment Report* for calculating CO<sub>2</sub> Eq. emissions. Supplemental data tables published with this *GHGIA* for download include all the tables presented in this chapter as well as tables with unweighted units reported as kilotons (kt).

## Methodological Framework

Emissions are estimated based on Volume 4 (Agriculture, Forestry and Other Lands [AFOLU]) of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) and the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2019), using country-specific data where available. Unless otherwise noted, methods are consistent with those used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2023* (Environmental Protection Agency [EPA], 2025), as noted in Table 6-2. Consistent with IPCC good practices, the inventory applies higher tier methods and approaches for more significant sources (e.g., Tier 2 and Tier 3 methods, which include use of country-specific methods and models, emission factors and other site-specific information), and where feasible for smaller sources.

To fill gaps in activity data typically occurring in the most recent years of the time series, several types of statistical techniques are used to extrapolate emissions estimates (see Volume 1, Chapter 5 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* [IPCC, 2006]). See Box 5-1 in the *Agriculture* chapter for more details on the specific extrapolation techniques used to forecast agriculture and LULUCF emissions, as well as discussion within category Methods sections.

**Table 6-2: Summary of Methods in the LULUCF Chapter**

Land-Use Category (CRT Code <sup>a</sup> )	Gases	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 Inventory (EPA, 2025)
<b>U.S. Land Representation</b>	<b>NA</b>	<b>Approach 3</b>	<b>No change</b>
<b>Forest Land Remaining Forest Land (4A1)</b>			
Changes in Forest Carbon Stocks	CO <sub>2</sub>	Tier 3	Entire CONUS is estimated with the same methodology
Non-CO <sub>2</sub> Emissions from Forest Fires	CH <sub>4</sub> , N <sub>2</sub> O	Tier 1, Tier 3	No change
N <sub>2</sub> O Emissions from Forest Soils	N <sub>2</sub> O	Tier 1	No change

(continued)

**Table 6-2: Summary of Methods in the LULUCF Chapter (continued)**

Land-Use Category (CRT Code <sup>a</sup> )	Gases	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 Inventory (EPA, 2025)
Non-CO <sub>2</sub> Emissions from Drained Organic Soils	CH <sub>4</sub> , N <sub>2</sub> O	Tier 1	No change
<b>Land Converted to Forest Land (4A2)</b>			
Changes in Forest Carbon Stocks	CO <sub>2</sub>	Tier 3	No change
<b>Cropland Remaining Cropland (4B1)</b>			
Changes in Ecosystem Carbon Stocks	CO <sub>2</sub>	Tier 1, Tier 2, Tier 3	No change
<b>Land Converted to Cropland (4B2)</b>			
Changes in All Ecosystem Carbon Stocks	CO <sub>2</sub>	Tier 1, Tier 2, Tier 3	No change
<b>Grassland Remaining Grassland (4C1)</b>			
Changes in All Ecosystem Carbon Stocks	CO <sub>2</sub>	Tier 2, Tier 3	No change
Non-CO <sub>2</sub> Emissions from Grassland Fires	CH <sub>4</sub> , N <sub>2</sub> O	Tier 1	No change
<b>Land Converted to Grassland (4C2)</b>			
Changes in all Ecosystem Carbon Stocks	CO <sub>2</sub>	Tier 1, Tier 2, Tier 3	No change
<b>Wetlands Remaining Wetlands (4D1)</b>			

(continued)

**Table 6-2: Summary of Methods in the LULUCF Chapter (continued)**

Land-Use Category (CRT Code <sup>a</sup> )	Gases	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 Inventory (EPA, 2025)
Changes in Organic Soil Carbon Stocks in Peatlands	CO <sub>2</sub>	Tier 1	No change
Non-CO <sub>2</sub> Emissions from Peatlands Remaining Peatlands	CH <sub>4</sub> , N <sub>2</sub> O	Tier 1	No change
Changes in Biomass, DOM, and Soil Carbon Stocks in Coastal Wetlands	CO <sub>2</sub>	Tier 1, Tier 2	2021 C-CAP activity data was incorporated
CH <sub>4</sub> Emissions from Coastal Wetlands Remaining Coastal Wetlands	CH <sub>4</sub>	Tier 1	2021 C-CAP activity data was incorporated
N <sub>2</sub> O Emissions from Coastal Wetlands Remaining Coastal Wetlands	N <sub>2</sub> O	Tier 1	No change
CH <sub>4</sub> Emissions from Flooded Land Remaining Flooded Land	CH <sub>4</sub>	Tier 1	No change
<b>Land Converted to Wetlands (4D2)</b>			
Changes in Biomass, DOM, and Soil Carbon Stocks in Land Converted to Coastal Wetlands	CO <sub>2</sub>	Tier 1, Tier 2	2021 C-CAP activity data was incorporated
CH <sub>4</sub> Emissions from Land Converted to Coastal Wetlands	CH <sub>4</sub>	Tier 1	2021 C-CAP activity data was incorporated
Changes in Carbon Stocks in Land Converted to Flooded Land	CO <sub>2</sub>	Tier 1	No change
CH <sub>4</sub> Emissions from Land Converted to Flooded Land	CH <sub>4</sub>	Tier 1	No change

(continued)

**Table 6-2: Summary of Methods in the LULUCF Chapter (continued)**

Settlements Remaining Settlements (4E1)			
Changes in Organic Soil Carbon Stocks	CO <sub>2</sub>	Tier 2	No change
Changes in Settlement Tree Carbon Stocks	CO <sub>2</sub>	Tier 2, Tier 3	No change
N <sub>2</sub> O Emissions from Settlement Soils	N <sub>2</sub> O	Tier 1	No change
Changes in Yard Trimming and Food Scrap Carbon Stocks in Landfills	CO <sub>2</sub>	Country-specific	No change
Land Converted to Settlements (4E2)			
Changes in All Ecosystem Carbon Stocks	CO <sub>2</sub>	Tier 1, Tier 2	No change

<sup>a</sup> Codes in parentheses represent common reporting table (CRT) codes. CRT codes are a classification system to organize quantitative reporting of detailed emission and removal data in standardized data tables (i.e., CRTs) to facilitate comparison of national inventory data and trends. The code reflects classification levels (e.g. sector, subsector, category, subcategory). Translating 4A1: 4 = LULUCF sector, A = forest subsector/land-use category, 1 = land-use conversion category (i.e., forest land remaining forest land).

## General Concepts Applicable to All Land-Use Categories

Below are general concepts that apply to all land-use categories (e.g., forest land, cropland) and are relevant to understanding emission and sink estimation approaches across this sector:

- This *GHGIA* estimates carbon stock changes across five major long-term carbon pools in terrestrial ecosystems (IPCC, 2006): aboveground biomass (carbon stored in all living plant biomass above the soil surface), belowground biomass (carbon contained in living roots of vegetation), dead wood (carbon stored in nonliving woody biomass such as standing dead trees, downed deadwood, and coarse woody debris), litter (carbon contained in smaller dead organic matter [DOM] lying on the soil surface), and soil organic carbon (carbon stored in soil organic matter). Not all carbon pools, such as DOM and litter, are accounted for in each land-use category, as each pool may not experience significant fluxes and instead is assumed to exist at a steady state under specific land uses.
- Emissions or removals in this *GHGIA* are estimated from the net annual change in carbon stocks across the main ecosystem pools (living biomass, dead wood, litter, and soil organic matter) within each land-use category (IPCC, 2006). As a consequence, estimates

presented in this *GHGIA* do not explicitly account for many short-term ecosystem carbon fluxes, such as carbon uptake and release from non-woody or rapidly cycling plant biomass (e.g., annual crops), autotrophic and heterotrophic soil respiration, and other fast carbon turnover processes. These fluxes largely cancel out over annual time scales and are only reflected indirectly through their contribution to net changes in the long-term carbon stocks that are reported.

- For the purposes of this *GHGIA* and pursuant to IPCC Guidelines, organic and mineral soils are considered distinct soil types that do not occur in the same geospatially explicit location. Organic soils, also referred to as histosols, are defined as soils with 12 to 20 percent organic carbon by weight, depending on clay content (Brady & Weil, 1999; Natural Resources Conservation Service [NRCS], 1999). All other soils in the *GHGIA* are considered mineral soils. Land-use areas and corresponding emissions and removals estimates throughout the LULUCF sector are often estimated separately by soil type.
- Land-use categories are classified into two groups: lands remaining in the same use and lands undergoing land-use change. If a parcel of land has not changed use category within the past 20 years, it is considered “remaining” in its current category, in line with the *2006 IPCC Guidelines* (IPCC, 2006). If a change has occurred within the last 20 years, the land is categorized as undergoing land-use change, defined by its current use and its most recent previous use (e.g., wetland converted to settlement). After this 20-year transition period in the new land-use change category, the land is then reclassified as remaining in that land-use category.
- As further described in the *Inventory of U.S. Greenhouse Gas Sources and Sinks: 1990-2023* (EPA, 2025) and the 2006 IPCC Guidelines (IPCC, 2006), given the complexity of tracking and estimating GHGs from the LULUCF sector and the need for practical inventory methods, all anthropogenic GHG emissions and removals associated with land use and management occur on managed land and should be reported in this *GHGIA*; here, the use of *managed land* serves as a proxy for anthropogenic activities (see Section 6.1).
- All net annual CO<sub>2</sub> emissions and removals associated with biomass are reported in the AFOLU sector. CO<sub>2</sub> emissions from biomass combustion used for energy are only recorded as a memo in the energy sector; these [memo] emissions are not included in the energy sector total to avoid double counting (IPCC, 2006). For example, if forests are harvested to produce energy, emissions from bioenergy combustion are reported for informational purposes only in the energy sector because the changes in forest carbon stocks are estimated in the LULUCF sector. See IPCC Frequently Asked Questions.<sup>2</sup>

## Quality Assurance/Quality Control

For all categories, the IPCC general and category-specific quality assurance/quality control (QA/QC) procedures were implemented. The procedures that were implemented involved checks that specifically focused on the activity data and methodology used for estimating each source of emissions and removals from the LULUCF sector. Emissions and removals trends were

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<sup>2</sup> <https://www.ipcc-nggip.iges.or.jp/faq/faq.html>

investigated to determine whether any corrective actions were needed. Minor corrective actions were taken as necessary.

## Uncertainty

The same uncertainty bounds reported in the *Inventory of U.S. Greenhouse Gas Sources and Sinks: 1990-2023* (EPA, 2025) were applied for each category and subcategory (as applicable) (see Table 6-45). A qualitative description of the uncertainties, along with the total category uncertainty estimate is provided within each category. Future iterations/versions of this *GHGIA* will review and update the quantified uncertainty associated with activity data, emission factors, and other input parameters.

## Future Areas for Improvement

Continuous improvement efforts are important for reflecting the latest science, reducing uncertainties to the extent practical in estimating emissions from land use and land-use change activities, especially for significant categories. For categories where the methodology has not changed in this *GHGIA* and is consistent with prior analysis, we endeavor to address those planned improvements identified in EPA (2025). Any improvements that have been incorporated into this *GHGIA* will be discussed in the Methods and Recalculations sections of those respective categories.

There are categories where additional methodological improvements will be needed, mostly due to challenges with data availability. A thorough review of alternative data sources and methods/models will also consider time-series consistency and recalculations. These are likely to occur in the following categories, often where modeling that relies on proprietary data (e.g., U.S. Department of Agriculture [USDA] National Resources Inventory [NRI] data used in the DayCent model) had previously been used:

- U.S. Land Representation
- Forest Land Remaining Forest Land – N<sub>2</sub>O Emissions from Forest Soils
- Cropland Remaining Cropland – Changes in Ecosystem Carbon Stocks
- Lands Converted to Cropland – Changes in All Ecosystem Carbon Stocks
- Grassland Remaining Grassland – Changes in All Ecosystem Carbon Stocks, Non-CO<sub>2</sub> Emissions from Grassland Fires
- Lands Converted to Grassland – Changes in all Ecosystem Carbon Stocks
- Settlements Remaining Settlements – Changes in Organic Soil Carbon Stocks
- Lands Converted to Settlements – Changes in All Ecosystem Carbon Stocks

Future versions of this *GHGIA* will specify more on scope, timing, and plans for phasing in improvements.



## 6.1 U.S. Land Representation

Information on land-use classification is needed to estimate GHG fluxes associated with activities in the LULUCF sector. The goal of a land representation analysis is to adequately, consistently, completely, and transparently (IPCC, 2006) represent these land-use categories and conversions to estimate changes in carbon stocks and non-CO<sub>2</sub> GHG fluxes.

Land-use categories include forest land, cropland, grassland, wetlands, settlements and other lands (see the General Concepts Applicable to All Land-Use Categories section). Within this *GHGIA*, land-use subcategories are also included for specific activities (e.g., flooded lands and coastal wetlands within the broader wetlands land-use category). These land-use categories and applicable subcategories are further stratified based on land management practices and factors including climate, soils, and ecological zones. See EPA (2025) for additional information pertaining to the definitions used to characterize land-use across the United States within this classification scheme and to estimate land-use areas.

Building upon the discussion in General Concepts Applicable to All Land-Use Categories section, in the United States and consistent with IPCC definitions, managed land is land in which the condition has been directly shaped or maintained through human intervention for purposes such as production (e.g., timber harvesting, livestock grazing, and managed land includes all croplands), infrastructure and development (managed land includes all settlement areas), resource extraction, conservation, or other uses (EPA, 2025). See Tables 6-3 and 6-4 for the land representation breakdown by managed and unmanaged land use and land-use change categories (Walters et al., 2026).

**Table 6-3: Managed and Unmanaged Land Area by Land-Use Categories for All 50 States (Thousands of Hectares)**

Land Use Categories	1990	2005	2020	2021	2022	2023	2024
<b>Managed Lands</b>	<b>886,533</b>	<b>886,530</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>
Forest	279,928	280,391	281,105	281,104	281,105	281,106	281,107
Cropland	173,868	165,576	158,658	158,410	158,229	158,141	158,076
Grassland	339,812	339,940	329,729	329,235	328,865	328,631	328,466
Settlements	33,558	40,387	50,115	50,600	50,826	51,049	51,241
Wetlands	38,759	38,919	44,711	44,972	45,298	45,516	45,603
Other	20,608	21,317	22,212	22,211	22,207	22,087	22,038
<b>Unmanaged Lands</b>	<b>49,708</b>	<b>49,711</b>	<b>49,710</b>	<b>49,710</b>	<b>49,710</b>	<b>49,710</b>	<b>49,710</b>
Forest	8,886	8,903	8,954	8,956	8,957	8,957	8,958

(continued)



**Table 6-3: Managed and Unmanaged Land Area by Land-Use Categories for All 50 States (Thousands of Hectares) (continued)**

Land Use Categories	1990	2005	2020	2021	2022	2023	2024
Cropland	0	0	0	0	0	0	0
Grassland	25,846	25,909	26,007	26,006	26,005	26,004	26,002
Settlements	0	0	0	0	0	0	0
Wetlands	4,242	4,180	4,055	4,055	4,055	4,056	4,056
Other	10,734	10,718	10,693	10,693	10,693	10,693	10,693
<b>Total Land Areas</b>	<b>936,241</b>	<b>936,241</b>	<b>936,241</b>	<b>936,241</b>	<b>936,241</b>	<b>936,241</b>	<b>936,241</b>
Forest	288,814	289,294	290,059	290,059	290,062	290,064	290,065
Cropland	173,868	165,576	158,658	158,410	158,229	158,141	158,076
Grassland	365,658	365,849	355,737	355,241	354,870	354,635	354,469
Settlements	33,558	40,387	50,115	50,600	50,826	51,049	51,241
Wetlands	43,001	43,099	48,766	49,027	49,353	49,572	49,659
Other	31,342	32,035	32,905	32,904	32,900	32,780	32,731

Note: Totals may not sum due to independent rounding.

**Table 6-4: Land Use and Land-Use Change for the U.S. Managed Land Base for All 50 States (Thousands of Hectares)**

Land Use and Land-Use Change Categories <sup>a</sup>	1990	2005	2020	2021	2022	2023	2024
<b>Total Forest Land</b>	<b>279,928</b>	<b>280,391</b>	<b>281,105</b>	<b>281,104</b>	<b>281,105</b>	<b>281,106</b>	<b>281,107</b>
FF	278,868	279,307	279,971	279,979	279,985	279,985	279,988
CF	154	133	106	104	101	101	101
GF	842	861	959	951	943	939	937
WF	14	16	29	33	41	47	48
SF	10	10	21	20	20	21	21
OF	40	66	19	17	15	14	12

(continued)

**Table 6-4: Land Use and Land-Use Change for the U.S. Managed Land Base for All 50 States (Thousands of Hectares) (continued)**

Land Use and Land-Use Change Categories <sup>a</sup>	1990	2005	2020	2021	2022	2023	2024
<b>Total Cropland</b>	<b>173,868</b>	<b>165,576</b>	<b>158,658</b>	<b>158,410</b>	<b>158,229</b>	<b>158,141</b>	<b>158,076</b>
CC	161,578	150,307	148,742	149,278	149,768	150,047	150,796
FC	144	67	42	41	40	40	39
GC	11,723	14,662	9,564	8,801	8,156	7,805	7,011
WC	146	191	87	84	75	71	67
SC	89	106	101	97	92	85	80
OC	187	244	121	109	98	94	83
<b>Total Grassland</b>	<b>339,812</b>	<b>339,940</b>	<b>329,729</b>	<b>329,235</b>	<b>328,865</b>	<b>328,631</b>	<b>328,466</b>
GG	330,270	319,209	314,085	314,456	315,025	315,516	316,817
FG	577	1,537	3,880	3,859	3,582	3,311	3,035
CG	8,246	17,196	10,575	9,803	9,218	8,757	7,553
WG	258	530	182	208	183	150	149
SG	58	146	150	142	135	134	132
OG	404	1,322	858	767	722	764	780
<b>Total Wetlands</b>	<b>38,759</b>	<b>38,919</b>	<b>44,711</b>	<b>44,972</b>	<b>45,298</b>	<b>45,516</b>	<b>45,603</b>
WW	38,077	37,404	38,485	38,769	39,109	39,398	39,513
FW	29	46	167	190	211	228	237
CW	202	536	1,167	1,155	1,133	1,094	1,076
GW	397	848	4,550	4,525	4,523	4,469	4,462
SW	3	1	106	91	90	90	90
OW	51	84	236	242	232	238	226
<b>Total Settlements</b>	<b>33,558</b>	<b>40,387</b>	<b>50,115</b>	<b>50,600</b>	<b>50,826</b>	<b>51,049</b>	<b>51,241</b>
SS	30,701	32,067	42,936	43,575	44,137	44,679	45,167

(continued)

**Table 6-4: Land Use and Land-Use Change for the U.S. Managed Land Base for All 50 States (Thousands of Hectares) (continued)**

Land Use and Land-Use Change Categories <sup>a</sup>	1990	2005	2020	2021	2022	2023	2024
FS	257	414	415	406	384	374	371
CS	1,241	3,577	2,651	2,565	2,435	2,300	2,163
GS	1,299	4,096	3,926	3,837	3,666	3,497	3,350
WS	5	31	46	69	66	66	64
OS	55	202	141	147	139	133	126
<b>Total Other Land</b>	<b>20,608</b>	<b>21,317</b>	<b>22,212</b>	<b>22,211</b>	<b>22,207</b>	<b>22,087</b>	<b>22,038</b>
OO	19,689	19,004	19,338	19,455	19,519	19,590	19,639
FO	36	70	93	93	93	77	77
CO	298	606	573	516	471	432	394
GO	465	1,404	1,933	1,876	1,848	1,716	1,664
WO	118	223	229	224	230	226	219
SO	3	11	46	47	46	46	45
<b>Total</b>	<b>886,533</b>	<b>886,530</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>	<b>886,531</b>

<sup>a</sup> C = cropland; F = forest land; G = grassland; O = other lands; S = settlements; W = wetlands. Lands remaining in the same land-use category are identified with the land-use abbreviation given twice (e.g., “GG” is grassland remaining grassland), and land-use change categories are identified with the previous land use abbreviation followed by the new land-use abbreviation (e.g., “WO” is wetland converted to other land).

Notes: All land areas reported in this table are considered managed. See the Planned Improvements section of EPA (2025) for discussion on plans to include U.S. territories in future Inventories and address land representation issues with wetlands. Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). See Section 6.1 of EPA (2025) for more details on the specific approach for harmonizing data for the land representation, definitions of land-use categories, and more details on the managed land proxy approach. This *GHGIA* used land-use area data based on an IPCC Approach 3, which reflects spatially explicit data on land use and conversions.

Four primary datasets have been used to estimate land use and land-use change area estimates for the United States: the USDA NRI,<sup>3</sup> the USDA Forest Service (USFS) Forest Inventory and

<sup>3</sup> NRI data are available at <https://www.nrcs.usda.gov/nri>

Analysis (FIA) database,<sup>4</sup> the Multi-Resolution Land Characteristics Consortium National Land Cover Dataset (NLCD),<sup>5</sup> and the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP).<sup>6</sup>

## Recalculations

The land representation estimates were recalculated from *the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025) with updated FIA data, National Land Cover Database (NLCD) (U.S. Geological Survey [USGS], 2024), and Coastal Change Analysis Program (C-CAP) (NOAA, 2024a; Walters et al., 2026). In terms of total managed land area, recalculations across the time series were almost zero; however, recalculations resulted in changes in area between the six land-use categories. The greatest changes were seen for wetlands, other lands, and settlements, with wetlands area increasing by an average of 3.5 percent across the 1990-2023 time series, followed by other lands at 3.0 percent and settlements by 1.8 percent. Changes were greater toward the end of the time series (i.e., 2018 onward), particularly for wetlands.

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<sup>4</sup> FIA data are available at <https://research.fs.usda.gov/programs/fia>

<sup>5</sup> NLCD data are available at <https://www.mrlc.gov/>

<sup>6</sup> C-CAP data are available at <https://coast.noaa.gov/digitalcoast/data/ccapregional.html>



## 6.2 Forest Land

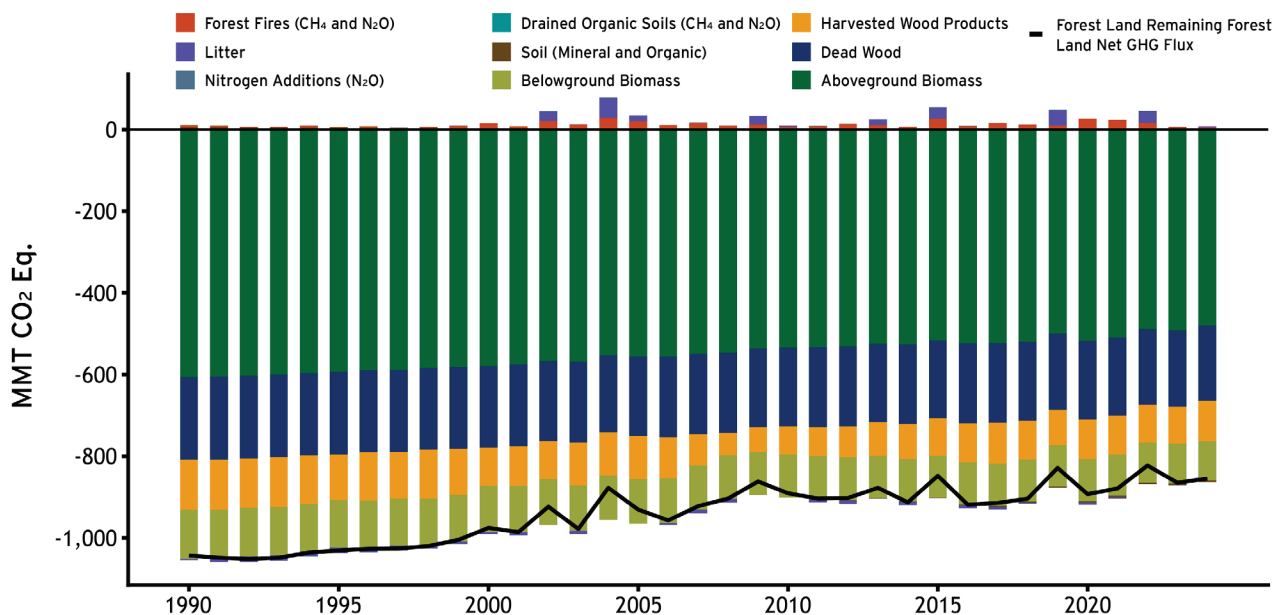
This land-use category includes all land with woody vegetation consistent with the USFS FIA definition of forest, as discussed in EPA (2025). GHG emissions and removals from forest land vary according to site-specific factors, forest or plantation types, stages of stand development, and forest land management practices (IPCC, 2006).

### 6.2.1 Forest Land Remaining Forest Land (Source Category 4A1)

Forest Land Remaining Forest Land is composed of the following (see Figure 6-2):

- Changes in Forest Carbon Stocks, including harvest wood products (CO<sub>2</sub>)
- Non-CO<sub>2</sub> Forest Fires (CH<sub>4</sub>, N<sub>2</sub>O)
- N<sub>2</sub>O from N Additions to Forest Soils (N<sub>2</sub>O)
- Emissions from Drained Organic Soils on Forest Land (N<sub>2</sub>O)

**Figure 6-2: Annual Net Forest Land Remaining Forest Land GHG Flux**



Note: Each category/bar includes estimates of annual net changes in all ecosystem carbon stocks and non-CO<sub>2</sub> emissions (where indicated). The "Forest Land Remaining Forest Land Net GHG Flux" line reflects the combined total emissions and removals occurring across all forest land remaining forest land carbon pools/subcategories.

## Changes in Forest Carbon Stocks

Carbon moves continuously between forest carbon pools and the atmosphere through natural processes such as photosynthesis, respiration, decomposition, and disturbances (e.g., fires or pest outbreaks), as well as through human activities like harvesting, thinning, and replanting. As previously noted in this chapter and consistent with IPCC guidance, net carbon stock change estimates include aboveground biomass, belowground biomass, dead wood, litter and soil organic carbon, and harvested wood products in use and those stored in solid waste disposal sites.

Changes in carbon stocks in the forest ecosystem and harvested wood pools associated with forest land remaining forest land were estimated to result in the net removal of 859.7 MMT CO<sub>2</sub> Eq. in 2024 (see Table 6-5). The estimated net uptake of carbon in the forest ecosystem was 759.2 MMT CO<sub>2</sub> Eq. in 2024 (Walters et al., 2026). As shown in Table 6-5, although there has been net carbon sequestration over the time series, the rate at which carbon is stored per acre (forest carbon density) is slowing, resulting in a decline in the forest land sink strength. This is in large part due to aging U.S. forests and increases in the frequency and severity of forest disturbances. From 1990 to 2024, the main factors affecting carbon fluxes on forest land were forest management, natural disturbances (e.g., wildfire; see Box 6-1), and past and current land-use changes.

**Table 6-5: Net Annual CO<sub>2</sub> Flux from Forest Ecosystem Pools in Forest Land Remaining Forest Land and Harvested Wood Pools (MMT CO<sub>2</sub> Eq.)**

Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Forest Ecosystem</b>	<b>(925.2)</b>	<b>(842.9)</b>	<b>(822.5)</b>	<b>(809.1)</b>	<b>(746.3)</b>	<b>(780.4)</b>	<b>(759.2)</b>
Aboveground Biomass	(606.6)	(555.7)	(517.6)	(510.1)	(489.1)	(491.8)	(480.0)
Belowground Biomass	(119.1)	(109.5)	(102.4)	(101.1)	(97.4)	(97.4)	(95.1)
Dead Wood	(201.5)	(194.3)	(192.9)	(191.1)	(185.3)	(186.5)	(183.8)
Litter	(3.6)	14.3	(6.0)	(3.2)	29.6	(0.8)	3.4
Soil (Mineral)	6.1	2.7	(3.8)	(3.7)	(4.2)	(4.1)	(3.9)
Soil (Organic)	(0.5)	(0.4)	0.2	0.2	0.2	0.1	0.1
<b>Harvested Wood</b>	<b>(123.8)</b>	<b>(106.0)</b>	<b>(96.8)</b>	<b>(94.7)</b>	<b>(92.8)</b>	<b>(90.9)</b>	<b>(100.5)</b>
Products in Use	(54.8)	(42.6)	(32.3)	(30.4)	(28.8)	(27.4)	(35.5)
Solid Waste Disposal Sites (SWDS)	(69.0)	(63.4)	(64.5)	(64.3)	(63.9)	(63.5)	(64.9)
<b>Total Net Flux</b>	<b>(1,049.0)</b>	<b>(949.0)</b>	<b>(919.3)</b>	<b>(903.7)</b>	<b>(839.1)</b>	<b>(871.3)</b>	<b>(859.7)</b>

Notes: Totals may not sum due to independent rounding. Parentheses indicate net sequestration. Forest ecosystem does not currently include CO<sub>2</sub> flux from drained organic soil.

## Box 6-1: CO<sub>2</sub> Emissions from Forest Fires

The U.S. forest inventory approach implicitly includes all carbon losses caused by disturbances such as forest fires, disease, insect outbreaks, and other drivers of forest biomass loss. In the event that a fire disturbance removes carbon from the forest, the National Forest Inventory reflects this loss of carbon when carbon stocks are remeasured following the disturbance and are compared to prior carbon stock estimates. Due to stakeholder interest, CO<sub>2</sub> emissions (Walters et al., 2026) from fire disturbance are presented in Table 6-6 for informational purposes.

**Table 6-6: Estimates of CO<sub>2</sub> (MMT per Year) Emissions from Forest Fires**

Emission Source	1990	2005	2020	2021	2022	2023	2024
Fires – CONUS and HI	13.1	30.4	216.8	201.2	84.3	39.7	24.3
Fires – AK	41.9	132.6	0.9	6.9	56.1	14.1	18.1
<b>Total</b>	<b>55.0</b>	<b>163.1</b>	<b>217.7</b>	<b>208.1</b>	<b>140.4</b>	<b>53.9</b>	<b>42.4</b>

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). The methods used to estimate forest carbon stock and stock changes are consistent across the conterminous United States (CONUS), as well as southeast Alaska. Methods differ for Hawaii and interior Alaska, as described by EPA (2025). The U.S. Forest Service FIA is the foundation to estimate carbon stocks and fluxes on forest land in the United States (Domke et al., 2022; Walters et al., 2026; Westfall et al., 2024).

## Recalculations

Updated FIA data and implementation of a consistent methodological approach across CONUS resulted in recalculations compared to prior analysis (EPA, 2025). The largest emissions and removal recalculation was seen in dead wood, with an average increase of 10.8 MMT CO<sub>2</sub> Eq. (loss of carbon) (a 5.2 percent decrease in carbon sequestration) across the time series. Overall, total changes in forest carbon stocks resulted in an average change of 10.4 MMT CO<sub>2</sub> Eq. (decrease in carbon sequestration) (–1.1 percent) compared to EPA (2025) data.

## Uncertainty

Estimates of forest carbon stocks are based on carbon estimates assigned to each national forest inventory plot. National forest inventory sampling errors and modeling errors introduce uncertainty in these estimates. Uncertainties associated with HWP are introduced from the production, trade, use, storage, and other data and parameters used to estimate HWP.

For this current *GHGIA*, the overall uncertainty of changes in forest carbon stocks is assumed to be similar to EPA (2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 1 and Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 9 percent below and 8.9 percent above the total forest net CO<sub>2</sub> flux in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Non-CO<sub>2</sub> Emissions from Forest Fires

As previously noted, the U.S. forest inventory approach used to calculate net forest carbon stocks includes all carbon losses due to fires; therefore, only non-CO<sub>2</sub> emissions from forest fires are presented in this section. These estimates reflect the combined total of both prescribed fires and wildfires. Totals also reflect both emissions from forest fires on forest land remaining forest land and land converted to forest land.

Fire patterns and resulting emissions are very dynamic across the time series. In 2024, non-CO<sub>2</sub> emissions from forest fires were estimated to be 2.5 MMT CO<sub>2</sub> Eq. of CH<sub>4</sub> and 1.9 MMT CO<sub>2</sub> Eq. of N<sub>2</sub>O (see Table 6-7). Across the time series, 2015 was the largest fire emissions year with an estimate of 26.6 MMT CO<sub>2</sub> Eq. In the United States, higher fuel loads and the increased length of the fire season and fire weather (e.g., drought, persistent heat) has led to increased fire severity and extent (Hoover & Smith, 2025).

**Table 6-7: Non-CO<sub>2</sub> Emissions from Forest Fires (MMT CO<sub>2</sub> Eq.)**

Gas	1990	2005	2020	2021	2022	2023	2024
CH <sub>4</sub>	3.3	10.4	16.4	15.1	9.5	3.6	2.5
N <sub>2</sub> O	2.4	7.2	9.6	9.2	6.2	2.4	1.9
<b>Total</b>	<b>5.8</b>	<b>17.6</b>	<b>26.0</b>	<b>24.3</b>	<b>15.7</b>	<b>6.0</b>	<b>4.4</b>

Note: Totals may not sum due to independent rounding.

## Methods

Overall calculation methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Emissions of non-CO<sub>2</sub> gases from forest fires were estimated using forest area burned, fuel, consumption, and emissions data consistent with latest IPCC methods (IPCC, 2019; Walters et al., 2026).

## Recalculations

Recalculations were implemented resulting from updates to the Monitoring Trends in Burn Severity (MTBS, n.d.) burned area activity data incorporated into fire non-CO<sub>2</sub> emissions estimates. These recalculations resulted in an average increase of 1.2 MMT CO<sub>2</sub> Eq. in total non-CO<sub>2</sub> forest fire emissions across the time series, representing a 19.8 average percent increase. The largest recalculation increase occurred in 2016, with a 104.7 percent increase compared to EPA (2025) data.

## Uncertainty

For this current *GHGIA*, the overall uncertainty of non-CO<sub>2</sub> emissions from forest fires was assumed to be similar to EPA (2025) given the use of the same methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 22 percent below and 22 percent above the CH<sub>4</sub> and N<sub>2</sub>O emissions from forest fires in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## N<sub>2</sub>O Emissions from Nitrogen Additions to Forest Soils

Additions of nitrogen fertilizers to forest land leads to direct and indirect N<sub>2</sub>O emissions. Estimates of N<sub>2</sub>O emissions from nitrogen additions to forest soils reflect both forest land remaining forest land as well as land converted to forest land.

Direct soil N<sub>2</sub>O emissions from forest land remaining forest land and land converted to forest land in 2024 were 0.3 MMT CO<sub>2</sub> Eq. (1.2 kt), and the indirect emissions were 0.1 MMT CO<sub>2</sub> Eq. (0.4 kt) (see Table 6-8). Total emissions for 2024 were 0.4 MMT CO<sub>2</sub> Eq. (1.5 kt), up 455 percent compared to 1990.

**Table 6-8: N<sub>2</sub>O Fluxes from Forest Soils (MMT CO<sub>2</sub> Eq. and kt N<sub>2</sub>O)**

N <sub>2</sub> O Fluxes from Forest Soils	1990	2005	2020	2021	2022	2023	2024
<b>Direct N<sub>2</sub>O Fluxes from Soils</b>							
MMT CO <sub>2</sub> Eq.	0.1	0.3	0.3	0.3	0.3	0.3	0.3
kt N <sub>2</sub> O	0.2	1.2	1.2	1.2	1.2	1.2	1.2
<b>Indirect N<sub>2</sub>O Fluxes from Soils</b>							
MMT CO <sub>2</sub> Eq.	+	0.1	0.1	0.1	0.1	0.1	0.1
kt N <sub>2</sub> O	0.1	0.4	0.4	0.4	0.4	0.4	0.4
<b>Total (MMT CO<sub>2</sub> Eq.)</b>	<b>0.1</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>	<b>0.4</b>
<b>Total (kt N<sub>2</sub>O)</b>	<b>0.3</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>

+ Does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). Tier 1 methodology and emission factors were applied.

## Recalculations

No recalculations were implemented for this current *GHGIA*.



## Uncertainty

N<sub>2</sub>O emissions from nitrogen additions to forest soils are influenced not only by nitrogen inputs and the amount of fertilized area but also by many other factors including soil carbon, oxygen availability, soil moisture, pH, temperature, tree planting, and harvesting cycles. The way these factors intersect is complex and leads to high uncertainty in the N<sub>2</sub>O flux. Uncertainties exist in the fertilization rates, annual area of forest lands receiving fertilizer, and the emission factors (EPA, 2025).

For this current *GHGIA*, the overall uncertainty of N<sub>2</sub>O emissions from nitrogen additions to forest soils is assumed to be similar to EPA (2025) given the use of the same methodology and data sources, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 86 percent below and 250 percent above the direct N<sub>2</sub>O flux, and 94 percent below and 267 percent above the indirect N<sub>2</sub>O flux from nitrogen additions in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Emissions from Drained Organic Soils on Forest Land

The draining of organic soils on forest land leads to N<sub>2</sub>O emissions. According to the IPCC (2014), organic soils that have been drained are those that existed as drained in the past and still persist in a drained condition or are newly drained soils within the inventory time series. In forest lands, soils are drained often to support forest management. Emissions from drained organic soils are influenced by land use, geographic region and climate, nutrient status, drainage level, exposure, and disturbance.

Total annual non-CO<sub>2</sub> emissions on forest land with drained organic soils in 2024 are estimated as 0.1 MMT CO<sub>2</sub> Eq. per year, as shown in Table 6-9. Totals reflect both estimates from forest land remaining forest land and land converted to forest land.

**Table 6-9: Non-CO<sub>2</sub> Emissions from Drained Organic Forest Soils (MMT CO<sub>2</sub> Eq.)**

Non-CO <sub>2</sub> Emissions from Drained Organic Soils	1990	2005	2020	2021	2022	2023	2024
CH <sub>4</sub> (MMT CO <sub>2</sub> Eq.)	+	+	+	+	+	+	+
N <sub>2</sub> O (MMT CO <sub>2</sub> Eq.)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<b>Total</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>

+ Does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Tier 1 methodology and emission factors were applied in line with IPCC (2014).

## Recalculations

No recalculations were implemented for this current *GHGIA*.

## Uncertainty

Uncertainties are primarily based on the sampling error associated with drained organic forest soil area and IPCC default emission factors. For the current *GHGIA*, the overall uncertainty of non-CO<sub>2</sub> emissions from drained organic forest soils is assumed to be similar to EPA (2025) given the use of the same methodology and data sources, calculated using the 2006 IPCC Guidelines Approach 1 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 69 percent below and 82 percent above the CH<sub>4</sub> estimate, and 118 percent below and 132 percent above the N<sub>2</sub>O estimate, with a total of uncertainty of 107 percent below and 121 percent above. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.2.2 Land Converted to Forest Land (Source Category 4A2)

Land converted to forest land captures carbon stock changes on lands converted from non-forest uses to forest. Generally, afforestation and reforestation of forests result in net carbon removals. Changes in carbon stocks in lands converted to forest land were estimated to result in net removal of 100.9 MMT CO<sub>2</sub> Eq. in 2024 (see Table 6-10).

**Table 6-10: Net CO<sub>2</sub> Flux from Forest Carbon Pools in Land Converted to Forest Land by Land-Use Change Category (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Cropland Converted to Forest Land</b>	<b>(18.4)</b>	<b>(18.2)</b>	<b>(18.0)</b>	<b>(18.0)</b>	<b>(18.0)</b>	<b>(18.0)</b>	<b>(18.0)</b>
Aboveground Biomass	(10.1)	(10.0)	(10.0)	(10.0)	(10.0)	(10.0)	(10.0)
Belowground Biomass	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)
Dead Wood	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)
Litter	(3.2)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)
Mineral soil	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
<b>Grassland Converted to Forest Land</b>	<b>(37.8)</b>	<b>(38.2)</b>	<b>(38.6)</b>	<b>(38.6)</b>	<b>(38.6)</b>	<b>(38.6)</b>	<b>(38.6)</b>
Aboveground Biomass	(21.6)	(21.7)	(22.0)	(22.0)	(22.0)	(22.0)	(22.0)
Belowground Biomass	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)	(2.7)
Dead Wood	(5.8)	(5.9)	(5.9)	(5.9)	(5.9)	(5.9)	(5.9)
Litter	(7.8)	(7.9)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)
Mineral soil	+	+	+	+	+	+	+
<b>Other Land Converted to Forest Land</b>	<b>(4.0)</b>	<b>(4.3)</b>	<b>(3.9)</b>	<b>(3.8)</b>	<b>(3.8)</b>	<b>(3.8)</b>	<b>(3.9)</b>
Aboveground Biomass	(1.6)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)
Belowground Biomass	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
Dead Wood	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Litter	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)
Mineral soil	(0.4)	(0.6)	(0.2)	(0.2)	(0.1)	(0.1)	(0.2)

(continued)

**Table 6-10: Net CO<sub>2</sub> Flux from Forest Carbon Pools in Land Converted to Forest Land by Land-Use Change Category (MMT CO<sub>2</sub> Eq.) (continued)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Settlements Converted to Forest Land</b>	<b>(32.9)</b>	<b>(32.7)</b>	<b>(32.6)</b>	<b>(32.5)</b>	<b>(32.5)</b>	<b>(32.5)</b>	<b>(32.5)</b>
Aboveground Biomass	(18.8)	(18.7)	(18.6)	(18.6)	(18.6)	(18.6)	(18.6)
Belowground Biomass	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)
Dead Wood	(6.2)	(6.2)	(6.2)	(6.2)	(6.2)	(6.2)	(6.2)
Litter	(4.7)	(4.7)	(4.7)	(4.7)	(4.7)	(4.7)	(4.7)
Mineral soil	+	+	+	+	+	+	+
<b>Wetlands Converted to Forest Land</b>	<b>(7.7)</b>	<b>(7.7)</b>	<b>(7.8)</b>	<b>(7.8)</b>	<b>(7.8)</b>	<b>(7.8)</b>	<b>(7.8)</b>
Aboveground Biomass	(4.1)	(4.1)	(4.1)	(4.1)	(4.1)	(4.1)	(4.1)
Belowground Biomass	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)
Dead Wood	(1.5)	(1.5)	(1.5)	(1.5)	(1.5)	(1.5)	(1.5)
Litter	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)
Mineral soil	+	+	+	+	+	+	+
<b>Total Aboveground Biomass Flux</b>	<b>(56.1)</b>	<b>(56.2)</b>	<b>(56.3)</b>	<b>(56.3)</b>	<b>(56.3)</b>	<b>(56.3)</b>	<b>(56.3)</b>
<b>Total Belowground Biomass Flux</b>	<b>(8.5)</b>	<b>(8.5)</b>	<b>(8.5)</b>	<b>(8.5)</b>	<b>(8.5)</b>	<b>(8.5)</b>	<b>(8.5)</b>
<b>Total Dead Wood Flux</b>	<b>(17.5)</b>	<b>(17.6)</b>	<b>(17.6)</b>	<b>(17.6)</b>	<b>(17.6)</b>	<b>(17.6)</b>	<b>(17.6)</b>
<b>Total Litter Flux</b>	<b>(18.0)</b>	<b>(18.1)</b>	<b>(18.2)</b>	<b>(18.2)</b>	<b>(18.2)</b>	<b>(18.2)</b>	<b>(18.2)</b>
<b>Total SOC (mineral) Flux</b>	<b>(0.7)</b>	<b>(0.9)</b>	<b>(0.3)</b>	<b>(0.3)</b>	<b>(0.2)</b>	<b>(0.2)</b>	<b>(0.3)</b>
<b>Total Net Flux</b>	<b>(100.8)</b>	<b>(101.2)</b>	<b>(100.9)</b>	<b>(100.9)</b>	<b>(100.8)</b>	<b>(100.8)</b>	<b>(100.9)</b>

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration. Forest ecosystem carbon stock changes from land conversion in interior Alaska, Hawaii, and the U.S. territories are currently included in the forest land remaining forest land section because there is insufficient data to separate changes in forest areas in these regions.

## Methods

Methods are based on the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025; Westfall et al., 2024). For all carbon pools, estimates for the 1990-2024 time series were based on the work of Walters et al. (2026).



## Recalculations

The methodological approach described above resulted in recalculations to all years of the 1990–2023 time series compared to EPA (2025). Total net carbon flux in this current *GHGIA* is approximately 2.9 percent less compared to prior analysis (EPA, 2025). On average across the time series, total net carbon flux decreased (less sequestration) by 2.6 MMT CO<sub>2</sub> Eq. (–2.5 percent).

## Uncertainty

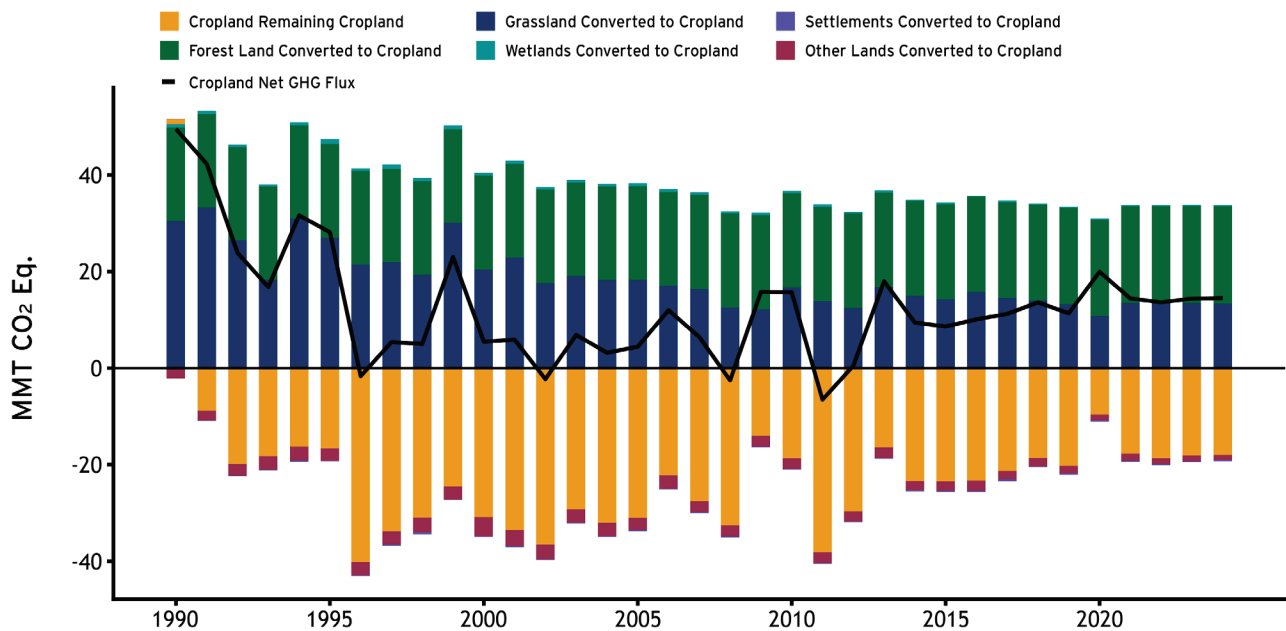
For this current *GHGIA*, the overall uncertainty of net carbon fluxes from lands converted to forest land is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources, calculated using the 2006 IPCC Guidelines Approach 1 and Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). The EPA (2025) confidence level indicates a range of approximately 11 percent below and 11 percent above the total lands converted to forest lands net flux. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.3 Cropland

This land-use category includes areas used for the production of crops for harvest and includes both cultivated and noncultivated lands, as discussed in EPA (2025). The definition of cropland is based on USDA NRI. The amount of carbon stored in and emitted or removed from permanent cropland depends on crop type, management practices, and soil and climate variables (IPCC, 2006). Figure 6-3 depicts the total emissions and removals contributions occurring on all cropland areas, including cropland remaining cropland and lands converted from each individual land-use category to cropland.

**Figure 6-3: Trends in Emissions and Removals from Croplands**



Note: Each category/bar includes estimates of annual net changes in all ecosystem carbon stocks for that land-use category. The 'Cropland Net GHG Flux' line reflects the combined total of all emissions and removals occurring across cropland remaining cropland and all land converted to cropland categories.

### 6.3.1 Cropland Remaining Cropland (Source Category 4B1)

The management of agricultural soils has an impact on soil conditions, soil microbial activity, and plant-soil interactions, and thus net carbon stocks. Example cropland management activities include planting, tillage, crop rotation and cover crop usage, residue management, and soil inputs. In addition to mineral and organic soil carbon, the carbon stored in perennial woody crops and agroforestry systems is also estimated.

In 2024, mineral soils were estimated to sequester 47.3 MMT CO<sub>2</sub> Eq., a 20.7 percent increase in carbon sequestration since 1990. Organic soils contributed emissions of 30.1 MMT CO<sub>2</sub> Eq. in

2024. In total, U.S. agricultural soils in cropland remaining cropland sequestered approximately 18.0 MMT CO<sub>2</sub> Eq. in 2024 (see Table 6-11). Soil organic carbon stock increases in cropland remaining cropland across the time series can be attributed, in part, to increased adoption of cropland management practices such as conservation tillage, winter cover crops, land set-asides, and precision agriculture. Adoption of these practices varies geographically, and research continues to assess the location-specific impact of these practices on soil organic carbon stocks, as well as the permanence of such effects (Ogle et al., 2023).

**Table 6-11: Net CO<sub>2</sub> Flux from Live Biomass and Soil Carbon Stock Changes in Cropland Remaining Cropland (MMT CO<sub>2</sub> Eq.)**

Carbon Pool	1990	2005	2020	2021	2022	2023	2024
Aboveground Live Biomass	6.1	0.6	0.8	0.8	0.8	0.8	0.8
Mineral Soils	(39.2)	(61.8)	(38.2)	(46.6)	(47.7)	(47.3)	(47.3)
Organic Soils	34.2	30.2	29.4	29.7	29.9	30.0	30.1
<b>Total Net Flux</b>	<b>1.0</b>	<b>(31.0)</b>	<b>(9.6)</b>	<b>(17.7)</b>	<b>(18.6)</b>	<b>(18.1)</b>	<b>(18.0)</b>

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

For biomass (non-woodland herbaceous biomass), a linear regression model with autoregressive integrated moving average (ARIMA) errors was used to forecast the net carbon flux for cropland remaining cropland from 2018 to 2024. Estimates from 1990 to 2017 are consistent with estimates from prior analysis (EPA, 2025).

For organic soils and mineral soils, a linear regression model with ARIMA errors was used to forecast the net carbon flux estimates from 2021 to 2024, since the 1990–2020 time series was based on prior runs from the DayCent model. Estimates from 1990 to 2020 are consistent with estimates from EPA (2025). For Tier 3 mineral soils, the same ARIMA approach was used with the addition of soybean and corn crop yield explanatory variables (surrogate data) (USDA National Agricultural Statistical Service [USDA-NASS], 2026a, 2026b) to forecast net carbon flux from 2021 to 2024.

## Recalculations

With the application of the updated forecasting approach, recalculations to the 2017–2023 time series ranged from –0.9 MMT CO<sub>2</sub> Eq. (4.83 percent) to 14.2 MMT CO<sub>2</sub> Eq. (44.38 percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) for cropland remaining cropland. The years 2021–2023 saw the greatest recalculations, primarily from mineral soils. There were no recalculations to estimates from 1990 to 2017.

## Uncertainty

Uncertainty in cropland remaining cropland emissions estimates stems from uncertainty associated with the management activity data, DayCent model parameterization and structure, and the emissions factors used. Additional uncertainty is contributed by the scaling of modeled emissions at individual NRI points to produce nationally comprehensive emissions estimates in EPA (2025). Finally, lack of estimation of agroforestry systems (currently not estimated due to a lack of activity data) also contributes to overall uncertainty in this source category, though this contribution is currently not quantified.

For this current *GHGIA*, the overall uncertainty of net carbon fluxes from cropland remaining cropland is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 1 and Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 229 percent below and 229 percent above the total cropland remaining cropland net flux. For the Tier 3 mineral soils carbon stocks (the largest contributor to net carbon flux), the uncertainty range is 112 percent below and 112 percent above, and 65 percent below and 65 percent above for organic soils. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.3.2 Land Converted to Cropland (Source Category 4B2)

Land converted to cropland reflects emissions and removals associated with conversion of other land categories to cropland primarily to be used to produce food, fiber, or forage. For example, conversion of forest land to cropland (i.e., deforestation) and conversion of grassland to cropland are the most significant sources of emissions from lands converted to croplands in the United States.

In 2024, land converted to cropland emitted approximately 32.6 MMT CO<sub>2</sub> Eq. as shown in Table 6-12. The largest losses of carbon came from aboveground biomass followed by mineral soils. Although total aboveground biomass was the largest loss of carbon in 2024, mineral soils have seen the greatest losses of carbon since 1990.

**Table 6-12: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter, and Biomass Carbon Stock Changes in Land Converted to Cropland by Land-Use Change Category (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Grassland Converted to Cropland</b>	<b>30.5</b>	<b>18.3</b>	<b>10.8</b>	<b>13.5</b>	<b>13.5</b>	<b>13.5</b>	<b>13.4</b>
Aboveground Live Biomass	3.3	1.2	0.3	0.3	0.3	0.3	0.3
Belowground Live Biomass	+	+	+	+	+	+	+
Dead Wood	0.1	0.1	+	+	+	+	+
Litter	+	+	+	+	+	+	+
Mineral Soils	24.6	13.7	8.0	10.6	10.6	10.7	10.6
Organic Soils	2.4	3.3	2.4	2.5	2.5	2.4	2.3
<b>Forest Converted to Cropland</b>	<b>19.4</b>	<b>19.4</b>	<b>20.0</b>	<b>20.0</b>	<b>20.1</b>	<b>20.1</b>	<b>20.2</b>
Aboveground Live Biomass	10.9	11.1	11.5	11.6	11.6	11.6	11.6
Belowground Live Biomass	1.9	1.9	2.0	2.0	2.0	2.0	2.0
Dead Wood	3.0	3.0	3.0	3.0	3.1	3.1	3.1
Litter	3.1	3.2	3.3	3.3	3.3	3.3	3.3
Mineral Soils	0.4	0.2	0.1	0.1	0.1	0.1	0.1
Organic Soils	0.1	+	+	+	+	+	+

*(continued)*

**Table 6-12: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter, and Biomass Carbon Stock Changes in Land Converted to Cropland by Land-Use Change Category (MMT CO<sub>2</sub> Eq.) (continued)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Other Lands Converted to Cropland</b>	(2.1)	(2.6)	(1.3)	(1.4)	(1.3)	(1.2)	(1.0)
Aboveground Live Biomass	(0.3)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Mineral Soils	(1.9)	(2.6)	(1.2)	(1.4)	(1.2)	(1.1)	(1.0)
Organic Soils	0.1	0.1	+	+	+	+	+
<b>Settlements Converted to Cropland</b>	+	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Aboveground Live Biomass	0.1	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Mineral Soils	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Organic Soils	+	+	+	+	+	+	+
<b>Wetlands Converted to Cropland</b>	0.7	0.6	0.3	0.3	0.3	0.2	0.2
Aboveground Live Biomass	0.0	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Mineral Soils	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Organic Soils	0.5	0.5	0.2	0.2	0.2	0.2	0.2
<b>Aboveground Live Biomass</b>	14.0	12.1	11.6	11.6	11.6	11.7	11.7
<b>Belowground Live Biomass</b>	1.9	1.9	2.0	2.0	2.0	2.0	2.0
<b>Dead Wood</b>	3.0	3.0	3.1	3.1	3.1	3.1	3.1
<b>Litter</b>	3.2	3.2	3.3	3.3	3.3	3.3	3.4
<b>Total Mineral Soil Flux</b>	23.2	11.3	6.9	9.3	9.4	9.7	9.7
<b>Total Organic Soil Flux</b>	3.2	3.9	2.7	2.9	2.8	2.7	2.6
<b>Total Net Flux</b>	48.5	35.5	29.6	32.2	32.3	32.5	32.6

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

For estimating biomass (aboveground and belowground) and DOM (dead wood and litter), a linear regression model with ARIMA errors was used to forecast the net carbon flux for land converted

to cropland from 2018 to 2024, as described in Box 5-1. Estimates from 1990 to 2017 are consistent with estimates from prior analysis (EPA, 2025).

For estimating organic soils and mineral soils, a linear regression model with ARIMA errors forecasted net carbon fluxes of land converted to cropland from 2021 to 2024. Observations (prior estimates from EPA [2025]) from 1990 to 2020 were used as the basis for forecasting as these were the latest time series available using runs from the DayCent model.

## Recalculations

Using the updated forecasting approach resulted in recalculations to the 2018–2023 time series. These recalculations range from  $-3.1$  MMT CO<sub>2</sub> Eq. ( $-8.66$  percent) to  $0.3$  MMT CO<sub>2</sub> Eq. ( $1.2$  percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025) for land converted to cropland. There were no recalculations to estimates from 1990 to 2017.

## Uncertainty

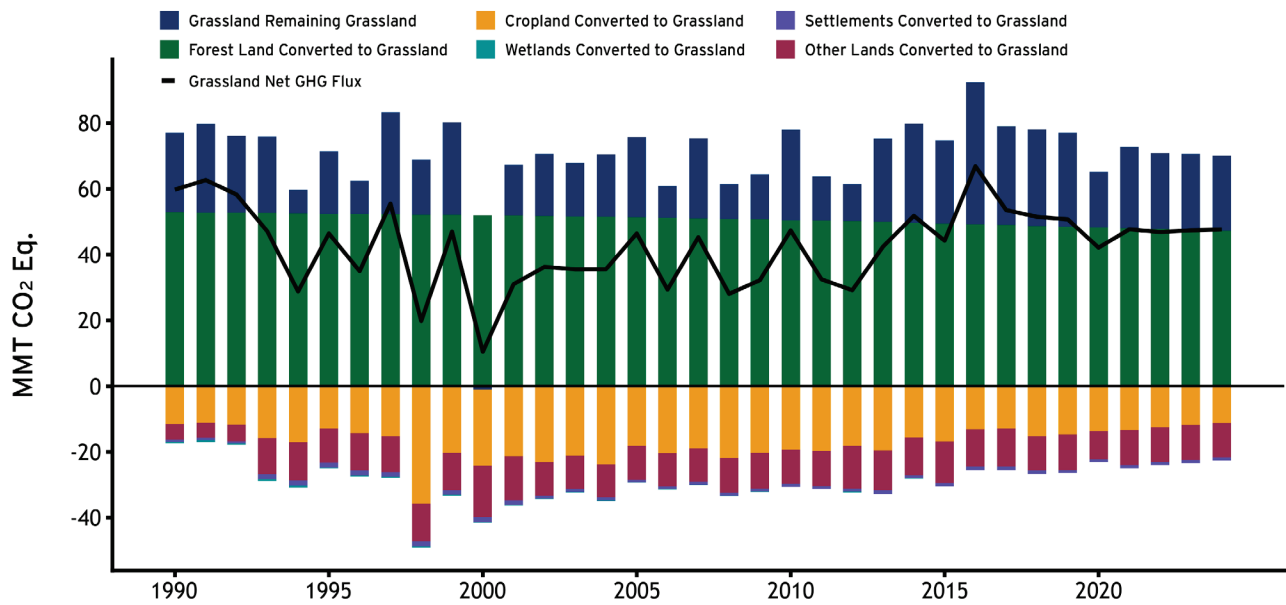
For this current *GHGIA*, the overall uncertainty of net carbon fluxes from land converted to cropland is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 105 percent below and 105 percent above the total land converted to cropland net flux. Uncertainty assessments 2024 are summarized at the end of this chapter in Table 6-45.



# 6.4 Grassland

This land-use category includes lands that do not meet the definition of cropland and whose vegetation is dominated by perennial grasses, grass-like plants (i.e., sedges and rushes), forbs, or shrubs, including pasture and rangeland that are primarily used for livestock grazing, and woodlands that do not meet the forest land definition (EPA, 2025). The definition of grassland is based on USDA NRI. Figure 6-4 depicts the total emissions and removals contributions occurring on all grassland areas, including grassland remaining grassland and lands converted from each individual land-use category to grassland.

**Figure 6-4: Trends in Emissions and Removals from Grasslands**



Note: Each category/bar includes estimates of annual net changes in all ecosystem carbon stocks. Grassland remaining grassland also includes CH<sub>4</sub> and N<sub>2</sub>O estimates from grassland fires. The “Grassland Net GHG Flux” line reflects the combined total emissions and removals occurring on grassland remaining grassland and all land converted to grassland categories.

## 6.4.1 Grassland Remaining Grassland (Source Category 4C1)

Grassland remaining grassland includes carbon stock changes in all six carbon pools, with the largest annual carbon stock changes occurring the mineral and organic soil carbon pool. Grazing intensity and conservation management, as well as climate variability, have an influence on carbon fluxes in grassland ecosystems (EPA, 2025).

In 2024, the net change in total carbon stocks resulted in CO<sub>2</sub> emissions of 22.0 MMT CO<sub>2</sub> Eq., 7.34 percent lower than 1990 (see Table 6-13). These losses are primarily due to net losses in mineral and organic soil carbon. From 1990 to 2024, there has been large variation in carbon

stocks from grassland remaining grasslands. For example, estimates of these total CO<sub>2</sub> fluxes range from 31.0 MMT CO<sub>2</sub> Eq. (emissions) in 1997 to –2.0 MMT CO<sub>2</sub> Eq. (sequestration) in 2000; the average annual change of carbon losses was 20.3 MMT CO<sub>2</sub> Eq. These changes result from variability in weather patterns and the corresponding effects of their interaction with land management practices.

**Table 6-13: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter and Biomass Carbon Stock Changes in Grassland Remaining Grassland (MMT CO<sub>2</sub> Eq.)**

Carbon Pool	1990	2005	2020	2021	2022	2023	2024
Aboveground Live Biomass	(2.5)	(2.1)	(1.3)	(1.2)	(1.1)	(1.1)	(1.0)
Belowground Live Biomass	(0.4)	(0.3)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Dead Wood	2.7	2.6	2.6	2.6	2.6	2.5	2.5
Litter	(0.4)	(0.2)	0.1	0.1	0.1	0.1	0.2
Mineral Soils	18.6	18.6	9.3	17.1	15.8	15.7	15.3
Organic Soils	6.1	5.1	5.5	5.4	5.4	5.4	5.5
<b>Total Net Flux</b>	<b>24.0</b>	<b>23.7</b>	<b>15.9</b>	<b>23.7</b>	<b>22.5</b>	<b>22.5</b>	<b>22.2</b>

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

For estimating biomass (woodland aboveground and belowground biomass) and DOM (dead wood and litter), a linear regression model with ARIMA errors was used to forecast the net carbon flux of grassland remaining grassland from 2018 to 2024, as described in Box 5-1 of the *Agriculture* chapter. Estimates from 1990 to 2017 are consistent with estimates from the prior analysis (EPA, 2025).

For estimating organic and mineral soils, a linear regression model with ARIMA errors was used to net carbon fluxes from 2021 to 2024. Years 1990–2020 were used as the basis for forecasting the use of runs from the DayCent model.

For the additions of biosolids, 2023 activity data values were held constant for 2024 due to data availability.

## Recalculations

Using the updated forecasting approach resulted in recalculations to the 2017–2023 time series. These recalculations range from 0.04 MMT CO<sub>2</sub> Eq. (0.1 percent difference) to 13.5 MMT CO<sub>2</sub> Eq. (131.6 percent difference) compared to the *Inventory of Greenhouse Gas Emissions and Sinks*:

1990-2023 (EPA, 2025) for grassland remaining grassland. There were no recalculations to estimates from 1990 to 2017.

## Uncertainty

For this current *GHGIA*, the overall uncertainty of net carbon fluxes from grassland remaining grassland is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 561 percent below and 561 percent above the total grassland remaining grassland net flux estimate. Uncertainty assessments and 2024 are summarized at the end of this chapter in Table 6-45.

## Non-CO<sub>2</sub> Emissions from Grassland Fires

Fires on grassland can occur naturally but are also prescribed for vegetation management and livestock grazing. Biomass burning emits non-CO<sub>2</sub> GHGs such as CH<sub>4</sub> and N<sub>2</sub>O, as well as CO and NO<sub>x</sub>. Any impact of grassland fires on carbon and CO<sub>2</sub> emissions and removals in grassland carbon pools is implicitly captured in the emissions and removals reported in the grassland ecosystem carbon stock changes section above (see Table 6-13). Emissions reported in this section include both emissions from grassland fires occurring on grassland remaining grassland as well as land converted to grassland.

Because the source of grassland fire ignition can be both natural and anthropogenic as part of rangeland management strategies, total burned grassland area and therefore grassland fire emissions vary widely across the time series due to both climatic patterns and shifts in management practices. Methane emissions from grassland fires in 2024 were 0.4 MMT CO<sub>2</sub> Eq., 4.3 percent lower than 2023 emissions and 213.5 percent higher than 1990 emissions, while N<sub>2</sub>O emissions from grassland fires in 2024 were 0.3 MMT CO<sub>2</sub> Eq., 4.4 percent lower than 2023 emissions and 213.4 percent higher than 1990 emissions (see Table 6-14).

**Table 6-14: CH<sub>4</sub> and N<sub>2</sub>O Emissions from Biomass Burning in Grassland (MMT CO<sub>2</sub> Eq.)**

Gas	1990	2005	2020	2021	2022	2023	2024
CH <sub>4</sub>	0.1	0.4	0.6	0.5	0.3	0.4	0.4
N <sub>2</sub> O	0.1	0.4	0.5	0.4	0.3	0.3	0.3
<b>Total</b>	<b>0.2</b>	<b>0.8</b>	<b>1.1</b>	<b>0.9</b>	<b>0.6</b>	<b>0.7</b>	<b>0.7</b>

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). As in the EPA (2025) report and as described in Box 5-1, an autoregressive moving

average (ARMA) extrapolation was applied to extrapolate CH<sub>4</sub> and N<sub>2</sub>O emissions from historical emissions estimates for years 2021-2024 of the time series.

## Recalculations

No recalculations were implemented for this source category compared to EPA (2025).

## Uncertainty

The uncertainty associated with non-CO<sub>2</sub> emissions from biomass burning on grasslands is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources. Uncertainty in emissions estimates for this source category were calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). Reported uncertainty is primarily derived from model errors associated with the application of the ARMA extrapolation relative to historical emissions estimates. For both CH<sub>4</sub> and N<sub>2</sub>O emissions from grassland fires, the EPA (2025) confidence level indicates a range of approximately 100 percent below and 120 percent above the reported emissions estimates. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.4.2 Land Converted to Grassland (Source Category 4C2)

Land converted to grassland includes carbon stock changes resulting from the conversation of other land uses to grasslands, which can impact carbon depending on the prior land use category and subsequent management. Forest to grassland conversions result in large emissions due to the loss of forest aboveground biomass, in particular, following conversion, whereas the conversion of cropland to grassland results in gains in soil carbon stocks with the cessation of intensive soil management that occurs in croplands. Across grassland ecosystems more broadly, prevailing weather and rangeland management and livestock grazing intensity can shape grassland vegetation and ecosystem carbon stocks, particularly soil carbon stocks.

In 2024, total land converted to grassland was a net source of emissions with a net carbon stock change of 24.7 MMT CO<sub>2</sub> Eq. (see Table 6-15).

**Table 6-15: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter, and Biomass Carbon Stock Changes for Land Converted to Grassland (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Cropland Converted to Grassland</b>	<b>(11.5)</b>	<b>(18.1)</b>	<b>(13.6)</b>	<b>(13.3)</b>	<b>(12.5)</b>	<b>(11.9)</b>	<b>(11.2)</b>
Aboveground Live Biomass	(1.4)	(1.3)	(4.4)	(4.4)	(4.4)	(4.4)	(4.4)
Belowground Live Biomass	+	+	+	+	+	+	+
Dead Wood	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)
Litter	(0.1)	+	+	+	+	+	+
Mineral Soils	(10.4)	(18.1)	(10.1)	(9.7)	(8.8)	(8.2)	(7.4)
Organic Soils	0.6	1.4	1.0	0.9	0.9	0.8	0.8
<b>Forest Converted to Grassland</b>	<b>52.9</b>	<b>51.4</b>	<b>48.2</b>	<b>48.0</b>	<b>47.7</b>	<b>47.5</b>	<b>47.2</b>
Aboveground Live Biomass	34.3	33.0	30.7	30.6	30.4	30.2	30.0
Belowground Live Biomass	4.7	4.6	4.3	4.3	4.3	4.2	4.2
Dead Wood	5.4	5.3	5.2	5.1	5.1	5.1	5.1
Litter	8.6	8.4	8.0	8.0	8.0	7.9	7.9
Mineral Soils	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Organic Soils	0.0	0.1	0.1	0.1	0.1	0.1	0.1

(continued)

**Table 6-15: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter, and Biomass Carbon Stock Changes for Land Converted to Grassland (MMT CO<sub>2</sub> Eq.) (continued)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Other Lands Converted to Grassland</b>	<b>(4.8)</b>	<b>(10.3)</b>	<b>(8.6)</b>	<b>(10.7)</b>	<b>(10.6)</b>	<b>(10.5)</b>	<b>(10.5)</b>
Aboveground Live Biomass	(0.9)	(0.8)	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)
Belowground Live Biomass	+	+	+	+	+	+	+
Dead Wood	+	+	+	+	+	+	+
Litter	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Mineral Soils	(3.8)	(9.4)	(8.1)	(10.1)	(10.0)	(9.9)	(9.8)
Organic Soils	+	+	0.1	0.1	0.1	0.1	0.1
<b>Settlements Converted to Grassland</b>	<b>(0.6)</b>	<b>(0.9)</b>	<b>(0.9)</b>	<b>(0.9)</b>	<b>(0.9)</b>	<b>(0.9)</b>	<b>(0.9)</b>
Aboveground Live Biomass	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
Belowground Live Biomass	+	+	+	+	+	+	+
Dead Wood	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Litter	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Mineral Soils	(0.1)	(0.3)	(0.4)	(0.5)	(0.5)	(0.5)	(0.5)
Organic Soils	+	+	+	+	+	+	+
<b>Wetlands Converted to Grassland</b>	<b>(0.4)</b>	<b>(0.1)</b>	<b>(0.0)</b>	<b>(0.0)</b>	<b>(0.0)</b>	<b>(0.0)</b>	<b>(0.0)</b>
Aboveground Live Biomass	(0.4)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Belowground Live Biomass	+	+	+	+	+	+	+
Dead Wood	+	+	+	+	+	+	+
Litter	+	+	+	+	+	+	+
Mineral Soils	+	+	+	+	+	+	+
Organic Soils	0.1	0.2	0.2	0.2	0.2	0.2	0.2
<b>Aboveground Live Biomass</b>	<b>31.4</b>	<b>30.4</b>	<b>25.4</b>	<b>25.2</b>	<b>25.0</b>	<b>24.8</b>	<b>24.6</b>
<b>Belowground Live Biomass</b>	<b>4.7</b>	<b>4.5</b>	<b>4.2</b>	<b>4.2</b>	<b>4.2</b>	<b>4.2</b>	<b>4.2</b>
<b>Dead Wood</b>	<b>5.1</b>	<b>5.1</b>	<b>5.0</b>	<b>5.0</b>	<b>4.9</b>	<b>4.9</b>	<b>4.9</b>

(continued)

**Table 6-15: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter, and Biomass Carbon Stock Changes for Land Converted to Grassland (MMT CO<sub>2</sub> Eq.) (continued)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
Litter	8.3	8.2	7.8	7.8	7.7	7.7	7.7
Total Mineral Soil Flux	(14.6)	(27.9)	(18.7)	(20.5)	(19.5)	(18.7)	(17.9)
Total Organic Soil Flux	0.7	1.8	1.4	1.4	1.3	1.2	1.2
Total Net Flux	35.6	21.9	25.1	23.0	23.7	24.1	24.7

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025).

For estimating biomass (including woodland conversion aboveground and belowground biomass) and DOM (dead wood and litter), a linear regression model with ARIMA errors was used to forecast the net carbon flux of land converted to grassland from 2018 to 2024. Estimates from 1990 to 2017 are consistent with estimates from prior analysis (EPA, 2025).

For estimating organic and mineral soils, a linear regression model with ARIMA errors was used to forecast net carbon fluxes of land converted to grassland from 2021 to 2024. Observations (prior estimates [EPA, 2025]) from 1990 to 2020 were used as the basis for forecasting as these were the latest time series available using runs from the DayCent model.

## Recalculations

Using the updated forecasting approach resulted in recalculations to the 2017-2023 time series. These recalculations result in increases to emissions ranging from 1.1 MMT CO<sub>2</sub> Eq. (4.4 percent) to 3.3 MMT CO<sub>2</sub> Eq. (15.7 percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025) for land converted to grassland. There were no recalculations to estimates from 1990 to 2017.

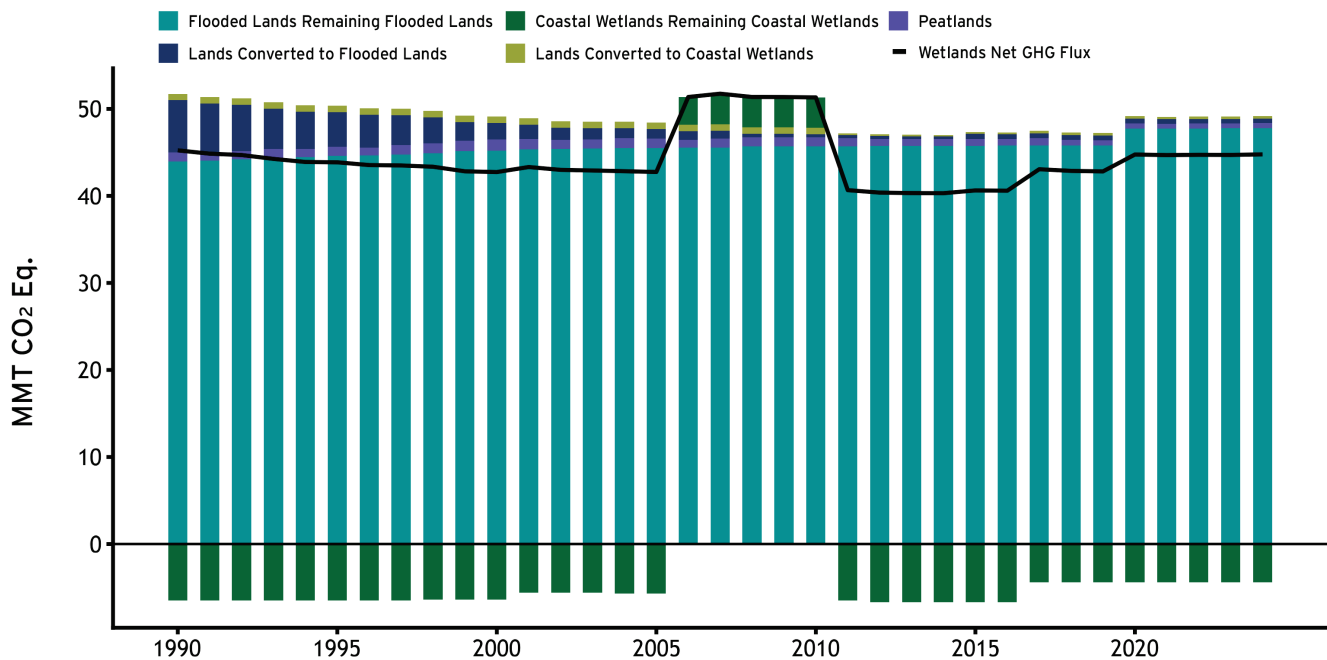
## Uncertainty

For this current *GHGIA*, the overall uncertainty of net carbon fluxes from land converted to grassland is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 206 percent below and 206 percent above the total land converted to grassland net flux estimate. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## 6.5 Wetlands

This land-use category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year, including lakes, reservoirs, and rivers, as well as all coastal wetlands, consistent with EPA (2025) definitions. It is important to note that some lands that are covered or saturated by water are not included as a wetland in this *GHGIA* because they meet the definition of another land-use category, as discussed further by EPA (2025). Figure 6-5 depicts the total emissions and removals contributions occurring on all wetland areas, including wetlands remaining wetlands and lands converted from each individual land-use category to wetlands.

**Figure 6-5: Trends in Emissions and Removals from Wetlands**



Note: Peatlands estimates include CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O estimates. Coastal wetlands remaining coastal wetlands and lands converted to coastal wetlands includes all net changes in biomass, dead organic matter, soil carbon stocks in coastal wetlands, as well as CH<sub>4</sub> and N<sub>2</sub>O (aquaculture) emissions. Flooded lands remaining flooded lands includes total CH<sub>4</sub> emissions and lands converted to flooded lands includes both CO<sub>2</sub> and CH<sub>4</sub> emissions. The “Total Wetlands Net GHG Flux” line reflects the combined total of all emissions and removals occurring across wetland remaining wetland and land converted to wetlands categories.

### 6.5.1 Wetlands Remaining Wetlands (Source Category 4D1)

Emissions and removals reported in the wetlands remaining wetlands land-use category include:

- Peatlands Remaining Peatlands (CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O)
- Coastal Wetlands Remaining Coastal Wetlands (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O)

- Flooded Land Remaining Flooded Land (CH<sub>4</sub>)

## Peatlands Remaining Peatlands

Managed peatlands are peatlands that are undergoing active peat extraction. This category includes on-site emissions from peat during extraction and off-site emissions from the horticultural use of peat (IPCC, 2006).

In 2024, total emissions from peatlands remaining peatlands were estimated to be 0.6 MMT CO<sub>2</sub> Eq., comprised mostly of CO<sub>2</sub> (see Table 6-16). Total emissions in 2024 were 12.2 percent greater than total emissions in 2023.

**Table 6-16: Emissions from Peatlands Remaining Peatlands (MMT CO<sub>2</sub> Eq.)**

Gas	1990	2005	2020	2021	2022	2023	2024
CO <sub>2</sub>	1.1	1.1	0.6	0.5	0.6	0.5	0.6
Off-Site	1.0	1.0	0.5	0.5	0.5	0.5	0.5
On-Site	0.1	0.1	+	+	+	+	+
CH <sub>4</sub> (on-site)	+	+	+	+	+	+	+
N <sub>2</sub> O (on-site)	+	+	+	+	+	+	+
<b>Total</b>	<b>1.1</b>	<b>1.1</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.5</b>	<b>0.6</b>

+ Does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Activity data for peat production in the United States were updated with the latest U.S. Geological Survey data (USGS, 2025) as shown in Tables 6-17 and 6-18, although no new data was available for Alaska.

**Table 6-17: Peat Production of Conterminous 48 States (kt)**

Type of Deposit	1990	2005	2020	2021	2022	2023	2024
Nutrient-Rich	595.1	657.6	343.4	291.6	308.7	279.0	315.0
Nutrient-Poor	55.4	27.4	10.6	32.4	34.3	31.0	35.0
<b>Total Production</b>	<b>692.0</b>	<b>685.0</b>	<b>354.0</b>	<b>324.0</b>	<b>343.0</b>	<b>310.0</b>	<b>350.0</b>

Note: Totals may not sum due to independent rounding.

**Table 6-18: Peat Production of Alaska (Thousand Cubic Meters)**

Alaska Peat Production	1990	2005	2020	2021	2022	2023	2024
Total Production	49.7	47.8	93.1	93.1	93.1	93.1	93.1

**Table 6-19: Peat Production Areas (Hectares)**

Area of Peat Production	1990	2005	2020	2021	2022	2023	2024
<b>Conterminous 48 States</b>							
Area of Drained Land	6,574	6,508	3,363	3,078	3,259	2,945	3,325
Area of Ditches	346	343	177	162	172	155	175
<b>Total Production</b>	<b>6,920</b>	<b>6,850</b>	<b>3,540</b>	<b>3,240</b>	<b>3,430</b>	<b>3,100</b>	<b>3,500</b>
<b>Alaska</b>							
Area of Drained Land	272	99	407	398	398	398	398
Area of Ditches	14	5	21	21	21	21	21
<b>Total Production</b>	<b>286</b>	<b>104</b>	<b>428</b>	<b>419</b>	<b>419</b>	<b>419</b>	<b>419</b>

Note: Totals may not sum due to independent rounding.

## Recalculations

Recalculations to the years 2022 and 2023 are associated with the use of updated USGS activity data (USGS, 2025). Incorporating the latest peat production data resulted in recalculations across the 2022-2023 recalculation window ranging from  $-0.01$  MMT CO<sub>2</sub> Eq. to  $-0.08$  MMT CO<sub>2</sub> Eq. (an average of  $-0.4$  percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). There were no recalculations to the 1990-2021 time series.

## Uncertainty

Uncertainty associated with peatlands emissions stems from the CONUS and Alaska peat production data and other factors used to estimate emissions such as bulk density.

For this current *GHGIA*, the overall uncertainty of peatland emissions is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). The EPA (2025) confidence level indicates a range of approximately 15 percent below and 16 percent above the CO<sub>2</sub> estimate, 58 percent below and 80 percent above for CH<sub>4</sub>, and 53 percent below and 54 percent above for the N<sub>2</sub>O emissions estimate for peatlands. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Coastal Wetlands Remaining Coastal Wetlands

Coastal wetlands include all privately and publicly owned mangroves and tidal marsh wetland areas (seagrasses are not currently estimated) along the oceanic shores that lie within the land representation of the United States. Currently, coastal wetlands in Alaska, Hawaii, and U.S. territories are not estimated. Soil carbon stock changes are estimated in organic and mineral soils, as are CH<sub>4</sub> emissions from microbial activity in certain coastal wetlands with lower salinity. Large emissions often occur when vegetated coastal wetlands are converted to unvegetated open water coastal wetlands following anthropogenic wetland degradation or the loss of coastal wetlands following large storms such as hurricanes or flooding from intense rain events. Conversion of vegetated coastal wetlands to open water results in the immediate loss of soil carbon stocks accumulated over decades to centuries as well as biomass carbon stocks.

In 2024, net biomass carbon fluxes in vegetated coastal wetlands remaining vegetated coastal wetlands resulted in emissions of 1.0 MMT CO<sub>2</sub> Eq., consistent with 2023 emissions but substantially higher than 1990 estimates, when biomass fluxes from vegetated coastal wetlands resulted in a marginal carbon sink (−0.01 MMT Eq. CO<sub>2</sub>). Net soil carbon fluxes in vegetated coastal wetlands remaining vegetated coastal wetlands in 2024 resulted in net removals of 12.0 MMT CO<sub>2</sub> Eq., a 0.5 percent decrease in removals relative to 2023 and a 4.1 percent decrease in removals relative to 1990. This trend corresponds to a decrease in overall vegetated coastal wetland area over the time series.

In vegetated coastal wetlands converted to unvegetated open water coastal wetlands, net biomass fluxes in 2024 resulted in net emissions of 0.13 MMT CO<sub>2</sub> Eq., net DOM carbon fluxes resulted in a small flux of emissions of 0.004 MMT CO<sub>2</sub> Eq., and net soil carbon fluxes resulted in emissions of 2.8 MMT CO<sub>2</sub> Eq. Emissions across all carbon pool stock changes in vegetated coastal wetlands converted to unvegetated open water in 2024 were consistent with 2023 estimates, while emissions relative to 1990 emissions were 67.0 percent higher. Trends in these emissions reflect an acceleration in loss of palustrine and estuarine emergent coastal wetlands to open water across the time series.

In contrast, enhanced conversion of unvegetated open water coastal wetlands converted to vegetated coastal wetlands resulted in net removals of 0.2 MMT CO<sub>2</sub> Eq. from biomass carbon fluxes, 0.004 MMT CO<sub>2</sub> Eq. from accumulated DOM, and 2.8 MMT CO<sub>2</sub> Eq. in net soil organic carbon sequestration (see Table 6-20). The magnitude of these removals is consistent with 2023 estimates, while removals relative to 1990 estimates are 467.0 percent higher for biomass carbon fluxes and 530.8 percent higher for soil organic carbon fluxes, while an extremely small net sequestration in the DOM carbon pool present in 1990 was completely eliminated in 2024. The significant conversion restoration of palustrine emergent wetlands from open water coastal wetlands in all climate zones across the time series was the key driver behind these emission trends.

**Table 6-20: Emissions and Removals from Coastal Wetlands Remaining Coastal Wetlands (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands</b>	<b>(12.6)</b>	<b>(12.6)</b>	<b>(11.3)</b>	<b>(11.2)</b>	<b>(11.2)</b>	<b>(11.1)</b>	<b>(11.1)</b>
Biomass Carbon Flux	+	+	1.0	1.0	1.0	1.0	1.0
Soil Carbon Flux	(12.5)	(12.6)	(12.3)	(12.2)	(12.1)	(12.1)	(12.0)
<b>Vegetated Coastal Wetlands Converted to Unvegetated Open Water Coastal Wetlands</b>	<b>1.8</b>	<b>2.6</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>
Biomass Carbon Flux	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dead Organic Matter Carbon Flux	+	+	+	+	+	+	+
Soil Carbon Flux	1.7	2.5	2.8	2.8	2.8	2.8	2.8
<b>Unvegetated Open Water Coastal Wetlands Converted to Vegetated Coastal Wetlands</b>	<b>+</b>	<b>(0.1)</b>	<b>(0.2)</b>	<b>(0.2)</b>	<b>(0.2)</b>	<b>(0.2)</b>	<b>(0.2)</b>
Biomass Carbon Flux	+	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Dead Organic Matter Carbon Flux	+	+	0.0	0.0	0.0	0.0	0.0
Soil Carbon Flux	+	+	+	+	+	+	+
<b>CH<sub>4</sub> Flux from Coastal Wetlands Remaining Coastal Wetlands</b>	<b>4.2</b>	<b>4.2</b>	<b>4.1</b>	<b>4.0</b>	<b>3.9</b>	<b>3.9</b>	<b>3.8</b>
<b>N<sub>2</sub>O Flux from Aquaculture in Coastal Wetlands (MMT CO<sub>2</sub> Eq.)</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>
<b>Total Biomass Carbon Flux</b>	<b>+</b>	<b>+</b>	<b>0.9</b>	<b>0.9</b>	<b>0.9</b>	<b>0.9</b>	<b>0.9</b>
<b>Total Dead Organic Matter Carbon Flux</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>Total Soil Carbon Flux</b>	<b>(10.8)</b>	<b>(10.1)</b>	<b>(9.5)</b>	<b>(9.4)</b>	<b>(9.2)</b>	<b>(9.3)</b>	<b>(9.2)</b>
<b>Total CH<sub>4</sub> Emissions</b>	<b>4.2</b>	<b>4.2</b>	<b>4.1</b>	<b>4.0</b>	<b>3.9</b>	<b>3.9</b>	<b>3.8</b>
<b>Total N<sub>2</sub>O Emissions</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>
<b>Total Carbon Flux</b>	<b>(10.8)</b>	<b>(10.1)</b>	<b>(8.6)</b>	<b>(8.5)</b>	<b>(8.4)</b>	<b>(8.4)</b>	<b>(8.3)</b>
<b>Total Net Flux from Coastal Wetlands Remaining Coastal Wetlands</b>	<b>(6.5)</b>	<b>(5.7)</b>	<b>(4.4)</b>	<b>(4.4)</b>	<b>(4.4)</b>	<b>(4.4)</b>	<b>(4.4)</b>

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Note: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.



## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). To determine coastal wetland areas, the most recent release of the C-CAP data product containing 2021 land cover estimates was used as the key activity data for the coastal wetland estimates was integrated into emissions calculations for this *GHGIA* (NOAA, 2024b). Coastal wetland areas were derived from 30-meter resolution C-CAP land cover data products for the years 1996, 2001, 2011, 2016 (NOAA, 2024a), and 2021 (NOAA, 2024b). The same seaward and inland geospatial boundaries used to define coastal wetlands in EPA (2025) were applied to the 2021 C-CAP product to isolate coastal wetlands that meet the land-use definition for the purposes of this *GHGIA* consistently across the time series. Area of coastal wetlands remaining coastal wetlands is presented in Table 6-21.

To extend the time series back to 1990 and forecast land cover estimates through 2024, annualized changes in vegetated coastal wetland remaining vegetated coastal wetlands, conversions of vegetated coastal wetland to and from unvegetated open water, and conversions of land from other land uses to coastal wetlands consistent with the closest date of available C-CAP product were applied to each remaining year of the time series. This extrapolation technique mirrors the technique applied in EPA (2025) to fill activity data gaps for years of the time series for which C-CAP data were unavailable.

**Table 6-21: Area of Coastal Wetlands Remaining Coastal Wetlands (hectares)**

Land Use	1990	2005	2020	2021	2022	2023	2024
Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands	2,975,477	2,985,783	2,893,307	2,893,307	2,853,934	2,834,231	2,814,529
Vegetated Coastal Wetlands Converted to Unvegetated Open Water Coastal Wetlands	1,720	2,515	2,854	2,854	2,854	2,854	2,854
Unvegetated Open Water Coastal Wetlands Converted to Vegetated Coastal Wetlands	952	1,769	6,438	6,438	6,438	6,438	6,438

## Recalculations

In this *GHGIA*, 2021 C-CAP land cover estimates were integrated into estimates, replacing coastal wetland areas from 2017 to 2023 that had been extrapolated from the 2016 C-CAP land cover product (NOAA, 2024a). This resulted in a recalculation of coastal wetland remaining coastal wetland ecosystem carbon flux estimates as well as CH<sub>4</sub> emission estimates. Across the 2021-

2023 recalculation time series, the average annual impact of this recalculation was a 2.0 percent (0.2 MMT CO<sub>2</sub> Eq.) decrease in removals across all carbon fluxes and a 5.8 percent (0.3 MMT CO<sub>2</sub> Eq.) decrease in CH<sub>4</sub> emissions in vegetated coastal wetlands remaining vegetated coastal wetlands. In vegetated coastal wetlands converted to unvegetated open water, the recalculation resulted in an average annual increase in emissions of 92.8 percent (1.4 MMT CO<sub>2</sub> Eq.) across all carbon pool fluxes from 2017 to 2023. In unvegetated open water coastal wetlands converted to vegetated coastal wetlands, the recalculation resulted in a 353.8 percent increase (0.2 MMT CO<sub>2</sub> Eq.) in removals on an annual basis across all carbon fluxes, indicating that extrapolations applied in EPA (2025) to complete the time series underestimated the restoration of coastal wetlands from open water coastal wetland ecosystems.

## Uncertainty

Uncertainty in overall coastal wetlands remaining coastal wetlands emissions stems from multiple sources, including the following: error associated in characterizing coastal wetland spatial extent from remote sensing imagery in the NOAA C-CAP land cover product, error in Tier 2 soil and biomass stock change factors derived from the literature, error in IPCC default emission factors (IPCC, 2013) for coastal wetland CH<sub>4</sub> emissions, and error in other IPCC default parameters such as root-to-shoot ratios. Additional uncertainty arises from the following sources, though these sources of error are not currently incorporated into the quantitative estimate of uncertainty presented here, primarily due to lack of data: assignment of climate region to coastal wetland areas by state and delineation of salinity conditions that allow for microbial methanogenesis and CH<sub>4</sub> emissions in estuarine coastal wetlands. See EPA (2025) for more details on uncertainty estimation for this source category.

For this current *GHGIA*, the overall uncertainty of coastal wetlands remaining coastal wetlands emissions and removals is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources in this *GHGIA*. Previous uncertainty estimates reported by EPA (2025) were calculated using the 2006 IPCC Guidelines Approach 1: Error Propagation methodology (IPCC, 2006). The *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025) presents upper and lower bounds defining the 95% confidence interval, with a range of approximately 36.5 percent below and 36.5 percent above total flux estimates in vegetated coastal wetlands remaining vegetated coastal wetlands, 32.0 percent below and 32.0 percent above total flux estimates in vegetated coastal wetlands converted to unvegetated open water coastal wetlands, and 33.3 percent below and 33.3 percent above total flux estimates for unvegetated open water coastal wetlands converted to vegetated coastal wetlands. Additional uncertainty information for individual carbon pool fluxes and gases associated with 2024 emissions is available at the end of this chapter in Table 6-45.



## N<sub>2</sub>O Emissions from Aquaculture in Coastal Wetlands

N<sub>2</sub>O emissions from aquaculture production result from the nitrification and denitrification of nitrogen-rich feed. NOAA estimates that the United States produced approximately 688 million pounds of farmed seafood<sup>7</sup> (NOAA, 2026) in 2023, the most recent year of available data.

In 2024, aquaculture production in the United States resulted in 0.1 MMT CO<sub>2</sub> Eq. (0.5 kt N<sub>2</sub>O) emissions, as shown in Table 6-22. The industry, and resulting emissions from production, has had fluctuations since 1990.

**Table 6-22: N<sub>2</sub>O Emissions from Aquaculture in Coastal Wetlands (MMT CO<sub>2</sub> Eq. and kt N<sub>2</sub>O)**

Emissions	1990	2005	2020	2021	2022	2023	2024
Emissions (MMT CO <sub>2</sub> Eq.)	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Emissions (kt N <sub>2</sub> O)	0.4	0.6	0.5	0.5	0.5	0.5	0.5

### Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Updated aquaculture production data was available through the most recent two NOAA Fisheries of the United States reports (NOAA, 2025, 2026). Values from 2019 were used to estimate emissions for 2020 and 2021. The production values for 2023 were used to calculate emissions for 2024. Aquaculture production data is presented in Table 6-23.

**Table 6-23. Aquaculture Production (kg)**

Activity	1990	2005	2020	2021	2022	2023	2024
Production	259,697	350,387	298,336	298,336	300,732	312,072	312,072

### Recalculations

Updated activity data, as noted in the Methods section, resulted in recalculations to the years 2022 and 2023. These recalculations resulted in insignificant changes compared to EPA (2025).

### Uncertainty

There is uncertainty regarding the estimate due to the inclusion of non-coastal wetland area fish production being included in the total production values used to estimate N<sub>2</sub>O emissions. For this current *GHGIA*, the overall uncertainty of aquaculture production emissions is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC,

<sup>7</sup> "Seafood includes wild and farmed aquatic organisms raised or fished for food production (both marine and freshwater harvested)" (NOAA, 2026).

2006). The EPA (2025) confidence level indicates a range of approximately 116 percent below and 116 percent above the N<sub>2</sub>O emissions estimate for aquaculture production. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Flooded Land Remaining Flooded Land

Flooded land remaining flooded land includes GHG emissions and carbon stock changes occurring on lands that remain flooded over time, including reservoirs and other managed water bodies (IPCC, 2019) often used for hydroelectric power, irrigation, drinking water supply, flood control, and other water management purposes.

Flooded land can emit CH<sub>4</sub> due to anaerobic decomposition of submerged organic matter, particularly in recently inundated areas and in systems with high organic inputs, high biomass production, and low oxygen status (IPCC, 2019). The trophic status of waterbodies can have a significant effect on CH<sub>4</sub> potential but is not directly factored into the current *GHGIA* methods. Methane is the primary source of emissions, but CO<sub>2</sub> and N<sub>2</sub>O emissions may also occur, depending on hydrologic and nutrient conditions (included in other sections of this *GHGIA*).

Methane emissions from reservoirs totaled 28.2 MMT CO<sub>2</sub> Eq. in 2024. Since 1990, the increase in CH<sub>4</sub> emissions is attributable to reservoirs transitioning from land converted to flooded land into the flooded land remaining flooded land. The majority of emissions are located in tropical climate states, primarily along the Gulf Coast. Emissions from other constructed waterbodies have remained relatively constant since 1990, totaling 17.6 MMT CO<sub>2</sub> Eq. in 2024. Total CH<sub>4</sub> emissions from flooded land remaining flooded land were approximately 45.8 MMT CO<sub>2</sub> Eq. Emissions from reservoirs and other constructed waterbodies are presented in Tables 6-24 through 6-27.

**Table 6-24: CH<sub>4</sub> Emissions from Flooded Land Remaining Flooded Land—Reservoirs (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
<b>Reservoirs</b>							
Surface Emissions	24.2	25.6	25.8	25.8	25.8	25.8	25.8
Downstream Emissions	2.2	2.3	2.3	2.3	2.3	2.3	2.3
<b>Total</b>	<b>26.4</b>	<b>27.9</b>	<b>28.1</b>	<b>28.2</b>	<b>28.2</b>	<b>28.2</b>	<b>28.2</b>

Note: Totals may not sum to due independent rounding.

**Table 6-25: Surface and Downstream CH<sub>4</sub> Emissions from Reservoirs in Flooded Land Remaining Flooded Land in 2024 (kt CH<sub>4</sub>)**

State	Surface	Downstream	Total
Alabama	22	2	24
Alaska	1	+	1
Arizona	14	1	15
Arkansas	25	2	27
California	36	3	40
Colorado	6	1	7
Connecticut	3	+	3
Delaware	4	+	4
District of Columbia	1	+	1
Florida	99	9	108
Georgia	33	3	36
Hawaii	1	+	1
Idaho	11	1	12
Illinois	16	1	17
Indiana	5	+	5
Iowa	6	1	7
Kansas	10	1	10
Kentucky	14	1	15
Louisiana	56	5	61
Maine	14	1	16
Maryland	12	1	13
Massachusetts	5	+	5
Michigan	9	1	10
Minnesota	20	2	22
Mississippi	19	2	21
Missouri	16	1	17
Montana	15	1	17
Nebraska	6	1	7
Nevada	17	2	18
New Hampshire	3	+	4
New Jersey	9	1	10
New Mexico	6	1	7

*(continued)*

**Table 6-25: Surface and Downstream CH<sub>4</sub> Emissions from Reservoirs in Flooded Land Remaining Flooded Land in 2024 (kt CH<sub>4</sub>) (continued)**

State	Surface	Downstream	Total
New York	17	1	18
North Carolina	32	3	35
North Dakota	14	1	15
Ohio	7	1	7
Oklahoma	25	2	28
Oregon	15	1	16
Pennsylvania	7	1	8
Puerto Rico	+	+	+
Rhode Island	1	+	1
South Carolina	36	3	40
South Dakota	12	1	13
Tennessee	19	2	21
Texas	131	12	143
Utah	21	2	23
Vermont	5	+	5
Virginia	24	2	27
Washington	22	2	23
West Virginia	3	+	3
Wisconsin	11	1	11
Wyoming	7	1	8
<b>Total</b>	<b>993</b>	<b>83</b>	<b>1,006</b>

+ Does not exceed than 0.5 kt.

Note: Totals may not sum due to independent rounding.

**Table 6-26: CH<sub>4</sub> Emissions from Flooded Land Remaining Flooded Land–Other Constructed Waterbodies (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
<b>Other Constructed Waterbodies</b>							
Canals and Ditches	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Freshwater Ponds	10.3	10.4	10.4	10.4	10.4	10.4	10.4
<b>Total</b>	<b>17.5</b>	<b>17.6</b>	<b>17.6</b>	<b>17.6</b>	<b>17.6</b>	<b>17.6</b>	<b>17.6</b>

Note: Totals may not sum due to independent rounding.

**Table 6-27: CH<sub>4</sub> Emissions from Other Constructed Waterbodies in Flooded Land Remaining Flooded Land in 2024 (kt CH<sub>4</sub>)**

State	Canals and Ditches	Freshwater Ponds	Total
Alabama	+	10.4	10.8
Alaska	+	+	+
Arizona	1.8	0.6	2.3
Arkansas	6.3	8.1	14.4
California	21.6	6.4	28
Colorado	6.9	3.2	10.1
Connecticut	+	1.7	1.8
Delaware	1	0.8	1.8
District of Columbia	+	+	+
Florida	50.4	27	77.4
Georgia	2.6	20.6	23.2
Hawaii	+	+	0.7
Idaho	7.5	1.2	8.7
Illinois	8.1	10.4	18.5
Indiana	8.7	9.6	18.3
Iowa	10.1	8.9	19
Kansas	1.8	14.8	16.6
Kentucky	0.6	7.5	8.1
Louisiana	12.2	4.4	16.6
Maine	0.6	3.3	3.9
Maryland	+	3.7	4
Massachusetts	1.3	2	3.3
Michigan	5.6	8.6	14.2
Minnesota	14.8	10.1	24.8
Mississippi	5.1	12.6	17.7
Missouri	6.6	19.8	26.4

*(continued)*

**Table 6-27: CH<sub>4</sub> Emissions from Other Constructed Waterbodies in Flooded Land Remaining Flooded Land in 2024 (kt CH<sub>4</sub>) (continued)**

State	Canals and Ditches	Freshwater Ponds	Total
Montana	6.4	8.8	15.2
Nebraska	7.7	7.3	14.9
Nevada	1.8	+	2.1
New Hampshire	+	1	1.1
New Jersey	2.1	2.5	4.5
New Mexico	+	2.1	2.4
New York	3.7	7.8	11.4
North Carolina	6.2	11.2	17.4
North Dakota	4.3	19.3	23.6
Ohio	1.8	9.3	11.1
Oklahoma	0.9	19	19.9
Oregon	5.3	2.3	7.6
Pennsylvania	+	4	4.2
Puerto Rico	+	+	+
Rhode Island	+	+	+
South Carolina	3.4	9.6	13
South Dakota	4.7	14.8	19.5
Tennessee	2.3	6.3	8.6
Texas	17.5	30.1	47.6
Utah	3.8	1.3	5.1
Vermont	+	0.7	1.1
Virginia	1.3	7	8.3
Washington	3.3	1.5	4.8
West Virginia	+	2	2
Wisconsin	0.7	3.6	4.4
Wyoming	5	3.6	8.6
<b>Total</b>	<b>258.4</b>	<b>371.9</b>	<b>630.3</b>

+ Indicates values less than 0.5 kt.

Note: Totals may not sum due to independent rounding.



## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). The flooded lands analysis was updated to matriculate existing waterbodies in land converted to flooded land (e.g., dams, reservoirs, ponds) to flooded land remaining flooded land based on age consistent with the 20-year transition approach per IPCC guidance. This is reflected in the state-level surface area shown in Tables 6-28 through 6-30.

**Table 6-28: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Reservoirs (millions of ha)**

State	1990	2005	2020	2021	2022	2023	2024
Alabama	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Alaska	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Arizona	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Arkansas	0.25	0.28	0.28	0.28	0.28	0.28	0.28
California	0.34	0.35	0.35	0.35	0.35	0.35	0.35
Colorado	0.07	0.08	0.08	0.08	0.08	0.08	0.08
Connecticut	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Delaware	0.05	0.05	0.05	0.05	0.05	0.05	0.05
District of Columbia	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Florida	0.69	0.70	0.70	0.70	0.70	0.70	0.70
Georgia	0.27	0.28	0.28	0.28	0.28	0.28	0.28
Hawaii	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Idaho	0.16	0.18	0.18	0.18	0.18	0.18	0.18
Illinois	0.15	0.16	0.20	0.20	0.20	0.20	0.20
Indiana	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Iowa	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Kansas	0.09	0.10	0.10	0.10	0.10	0.10	0.10
Kentucky	0.16	0.17	0.17	0.17	0.17	0.17	0.17
Louisiana	0.39	0.40	0.40	0.40	0.40	0.40	0.40
Maine	0.25	0.26	0.27	0.27	0.27	0.27	0.27
Maryland	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Massachusetts	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Michigan	0.15	0.16	0.17	0.17	0.17	0.17	0.17

(continued)

**Table 6-28: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Reservoirs (millions of ha) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Minnesota	0.36	0.36	0.37	0.37	0.37	0.37	0.37
Mississippi	0.17	0.18	0.18	0.18	0.18	0.18	0.18
Missouri	0.18	0.20	0.20	0.20	0.20	0.20	0.20
Montana	0.27	0.28	0.28	0.28	0.28	0.28	0.28
Nebraska	0.06	0.07	0.07	0.07	0.07	0.07	0.07
Nevada	0.08	0.09	0.09	0.09	0.09	0.09	0.09
New Hampshire	0.06	0.06	0.06	0.06	0.06	0.06	0.06
New Jersey	0.12	0.12	0.12	0.12	0.12	0.12	0.12
New Mexico	0.05	0.05	0.05	0.05	0.05	0.05	0.05
New York	0.28	0.28	0.29	0.29	0.29	0.29	0.29
North Carolina	0.39	0.40	0.40	0.40	0.40	0.40	0.40
North Dakota	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Ohio	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Oklahoma	0.26	0.29	0.29	0.29	0.29	0.29	0.29
Oregon	0.20	0.21	0.21	0.21	0.21	0.21	0.21
Pennsylvania	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Puerto Rico	+	+	+	+	+	+	+
Rhode Island	0.02	0.02	0.02	0.02	0.02	0.02	0.02
South Carolina	0.30	0.31	0.32	0.32	0.32	0.32	0.32
South Dakota	0.22	0.22	0.23	0.23	0.23	0.23	0.23
Tennessee	0.18	0.23	0.23	0.23	0.23	0.23	0.23
Texas	0.60	0.67	0.67	0.67	0.67	0.67	0.67
Utah	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Vermont	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Virginia	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Washington	0.22	0.22	0.22	0.22	0.22	0.22	0.22
West Virginia	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Wisconsin	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Wyoming	0.11	0.13	0.13	0.13	0.13	0.13	0.13
<b>Total</b>	<b>9.06</b>	<b>9.51</b>	<b>9.63</b>	<b>9.63</b>	<b>9.63</b>	<b>9.64</b>	<b>9.64</b>

+ Indicates values less than 0.005 million ha.

Note: Totals may not sum due to independent rounding.

**Table 6-29: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Canals and Ditches (hectares)**

State	1990	2005	2020	2021	2022	2023	2024
Alabama	1,125	1,125	1,125	1,125	1,125	1,125	1,125
Alaska	217	217	217	217	217	217	217
Arizona	4,221	4,221	4,221	4,221	4,221	4,221	4,221
Arkansas	15,155	15,155	15,155	15,155	15,155	15,155	15,155
California	51,834	51,834	51,834	51,834	51,834	51,834	51,834
Colorado	16,694	16,694	16,694	16,694	16,694	16,694	16,694
Connecticut	249	249	249	249	249	249	249
Delaware	2,405	2,405	2,405	2,405	2,405	2,405	2,405
District of Columbia	4	4	4	4	4	4	4
Florida	121,192	121,192	121,192	121,192	121,192	121,192	121,192
Georgia	6,175	6,175	6,175	6,175	6,175	6,175	6,175
Hawaii	1,170	1,170	1,170	1,170	1,170	1,170	1,170
Idaho	18,080	18,080	18,080	18,080	18,080	18,080	18,080
Illinois	19,394	19,394	19,394	19,394	19,394	19,394	19,394
Indiana	21,026	21,026	21,026	21,026	21,026	21,026	21,026
Iowa	24,174	24,174	24,174	24,174	24,174	24,174	24,174
Kansas	4,397	4,397	4,397	4,397	4,397	4,397	4,397
Kentucky	1,506	1,506	1,506	1,506	1,506	1,506	1,506
Louisiana	29,310	29,310	29,310	29,310	29,310	29,310	29,310
Maine	1,422	1,422	1,422	1,422	1,422	1,422	1,422
Maryland	641	641	641	641	641	641	641
Massachusetts	3,239	3,239	3,239	3,239	3,239	3,239	3,239
Michigan	13,361	13,361	13,361	13,361	13,361	13,361	13,361
Minnesota	35,480	35,480	35,480	35,480	35,480	35,480	35,480
Mississippi	12,196	12,196	12,196	12,196	12,196	12,196	12,196
Missouri	15,804	15,804	15,804	15,804	15,804	15,804	15,804

(continued)

**Table 6-29: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Canals and Ditches (hectares) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Montana	15,453	15,453	15,453	15,453	15,453	15,453	15,453
Nebraska	18,429	18,429	18,429	18,429	18,429	18,429	18,429
Nevada	4,324	4,324	4,324	4,324	4,324	4,324	4,324
New Hampshire	462	462	462	462	462	462	462
New Jersey	4,936	4,936	4,936	4,936	4,936	4,936	4,936
New Mexico	750	750	750	750	750	750	750
New York	8,809	8,809	8,809	8,809	8,809	8,809	8,809
North Carolina	14,873	14,873	14,873	14,873	14,873	14,873	14,873
North Dakota	10,230	10,230	10,230	10,230	10,230	10,230	10,230
Ohio	4,282	4,282	4,282	4,282	4,282	4,282	4,282
Oklahoma	2,068	2,068	2,068	2,068	2,068	2,068	2,068
Oregon	12,753	12,753	12,753	12,753	12,753	12,753	12,753
Pennsylvania	393	393	393	393	393	393	393
Puerto Rico	656	656	656	656	656	656	656
Rhode Island	6	6	6	6	6	6	6
South Carolina	8,064	8,064	8,064	8,064	8,064	8,064	8,064
South Dakota	11,402	11,402	11,402	11,402	11,402	11,402	11,402
Tennessee	5,494	5,494	5,494	5,494	5,494	5,494	5,494
Texas	41,969	41,969	41,969	41,969	41,969	41,969	41,969
Utah	9,196	9,196	9,196	9,196	9,196	9,196	9,196
Vermont	1,120	1,120	1,120	1,120	1,120	1,120	1,120
Virginia	3,138	3,138	3,138	3,138	3,138	3,138	3,138
Washington	8,010	8,010	8,010	8,010	8,010	8,010	8,010
West Virginia	40	40	40	40	40	40	40
Wisconsin	1,779	1,779	1,779	1,779	1,779	1,779	1,779
Wyoming	12,110	12,110	12,110	12,110	12,110	12,110	12,110
<b>Total</b>	<b>621,220</b>	<b>621,220</b>	<b>621,220</b>	<b>621,220</b>	<b>621,220</b>	<b>621,220</b>	<b>621,220</b>

Note: Totals may not sum due to independent rounding.

**Table 6-30: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Freshwater Ponds (hectares)**

State	1990	2005	2020	2021	2022	2023	2024
Alabama	56,255	56,619	56,643	56,643	56,643	56,643	56,643
Alaska	2,192	2,199	2,199	2,199	2,199	2,199	2,199
Arizona	3,016	3,056	3,069	3,069	3,069	3,069	3,069
Arkansas	43,706	44,041	44,043	44,043	44,043	44,043	44,043
California	34,981	35,155	35,230	35,230	35,236	35,242	35,245
Colorado	17,161	17,380	17,412	17,412	17,412	17,415	17,425
Connecticut	9,464	9,534	9,539	9,539	9,539	9,539	9,539
Delaware	4,099	4,102	4,102	4,102	4,102	4,102	4,102
District of Columbia	11	11	11	11	11	11	11
Florida	147,166	147,252	147,283	147,288	147,290	147,290	147,293
Georgia	110,800	112,443	112,521	112,521	112,521	112,521	112,524
Hawaii	921	929	931	931	931	931	931
Idaho	6,293	6,394	6,394	6,395	6,395	6,395	6,395
Illinois	56,236	56,752	56,844	56,845	56,849	56,850	56,850
Indiana	51,757	52,209	52,286	52,286	52,295	52,302	52,307
Iowa	45,414	47,366	48,676	48,770	48,800	48,809	48,822
Kansas	78,258	80,482	80,581	80,603	80,604	80,618	80,637
Kentucky	40,608	40,967	41,001	41,001	41,001	41,001	41,001
Louisiana	24,017	24,137	24,153	24,153	24,153	24,154	24,162
Maine	18,046	18,070	18,079	18,079	18,079	18,079	18,079
Maryland	20,045	20,214	20,274	20,276	20,277	20,277	20,278
Massachusetts	10,733	10,776	10,826	10,827	10,831	10,833	10,836
Michigan	46,821	46,960	47,011	47,011	47,011	47,011	47,011
Minnesota	54,666	54,905	54,982	54,991	54,999	54,999	54,999
Mississippi	68,315	68,638	68,765	68,771	68,779	68,789	68,792
Missouri	104,956	108,267	108,399	108,406	108,411	108,417	108,430
Montana	47,596	47,942	47,963	47,963	47,963	48,049	48,049

(continued)

**Table 6-30: State Breakdown of Surface Area in Flooded Land Remaining Flooded Land—Freshwater Ponds (hectares) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Missouri	104,956	108,267	108,399	108,406	108,411	108,417	108,430
Montana	47,596	47,942	47,963	47,963	47,963	48,049	48,049
Nebraska	38,290	39,492	39,720	39,729	39,733	39,742	39,752
Nevada	1,833	1,836	1,875	1,880	1,883	1,887	1,887
New Hampshire	5,084	5,184	5,228	5,229	5,229	5,229	5,229
New Jersey	13,577	13,603	13,617	13,617	13,617	13,617	13,617
New Mexico	11,202	11,226	11,251	11,254	11,258	11,260	11,260
New York	42,126	42,381	42,494	42,499	42,499	42,510	42,510
North Carolina	60,787	61,231	61,315	61,317	61,318	61,318	61,318
North Dakota	105,261	105,382	105,502	105,510	105,513	105,524	105,528
Ohio	50,221	50,562	50,787	50,799	50,801	50,818	50,820
Oklahoma	101,972	103,867	103,960	103,966	103,974	103,977	103,996
Oregon	12,490	12,643	12,690	12,690	12,690	12,690	12,707
Pennsylvania	21,686	21,917	21,955	21,956	21,956	21,956	21,956
Puerto Rico	406	406	406	406	406	406	406
Rhode Island	2,198	2,206	2,213	2,213	2,213	2,213	2,213
South Carolina	51,627	52,222	52,455	52,455	52,455	52,455	52,455
South Dakota	80,332	80,600	80,679	80,687	80,687	80,702	80,709
Tennessee	33,954	34,346	34,390	34,390	34,391	34,391	34,391
Texas	161,800	164,486	164,580	164,581	164,581	164,588	164,589
Utah	6,898	6,983	6,994	6,994	6,994	7,004	7,004
Vermont	3,509	3,576	3,587	3,587	3,587	3,587	3,587
Virginia	38,292	38,350	38,354	38,354	38,354	38,354	38,354
Washington	7,943	8,071	8,113	8,115	8,116	8,117	8,117
West Virginia	10,738	10,853	10,887	10,887	10,887	10,887	10,893
Wisconsin	19,591	19,738	19,747	19,747	19,747	19,747	19,757
Wyoming	19,059	19,280	19,377	19,379	19,383	19,421	19,429
<b>Total</b>	<b>2,004,411</b>	<b>2,027,241</b>	<b>2,031,395</b>	<b>2,031,606</b>	<b>2,031,716</b>	<b>2,031,987</b>	<b>2,032,157</b>

Note: Totals may not sum due to independent rounding.

## Recalculations

No recalculations were implemented for this current *GHGIA*.

## Uncertainty

Uncertainty stems from the spatial data (area estimates) from the underlying activity data (e.g., National Hydrography Dataset [NHD], National Wetlands Inventory [NWI], and the National Inventory of Dams [NID]). For this current *GHGIA*, the overall uncertainty of CH<sub>4</sub> emissions from flooded land remaining flooded land is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). The EPA (2025) confidence level indicates a range of approximately 0.8 percent below and 2 percent above the reservoir CH<sub>4</sub> estimate and 1.4 percent below and 1.2 percent above the other constructed waterbodies CH<sub>4</sub> estimate. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.5.2 Land Converted to Wetlands (Source Category 4D2)

### Land Converted to Coastal Wetlands

Land converted to coastal wetlands includes carbon stock changes associated with lands converted from other land uses to coastal wetlands, often through restoration activities, sediment deposition, or other natural processes that reestablish tidal influence. In the United States, certain regions see increased carbon sequestration through restoration initiatives. Conversion of cropland, grassland, settlements, and other land to coastal wetlands generally results in increased carbon sinks due to larger biomass and soil carbon stocks and accumulation rates in coastal wetlands relative to carbon stocks in other land-use categories. In contrast, conversion of forests to coastal wetlands results in loss of biomass and DOM carbon stocks, buffered to some extent by increases in soil carbon stocks when forests are converted to coastal wetlands. These competing dynamics have resulted in net fluxes from land converted to coastal wetland oscillating between marginal source and sink status, largely following trends in forest area converted to coastal wetlands.

In 2024, conversion of lands from other land uses to coastal wetlands resulted in emissions of 0.20 MMT CO<sub>2</sub> Eq., losses of DOM following land-use conversion to coastal wetlands resulted in emissions of 0.04 MMT CO<sub>2</sub> Eq., and soil carbon stock changes across all land-use categories converted to coastal wetlands resulted in net removals of 0.12 MMT CO<sub>2</sub> Eq. Methane emissions from lands converted to coastal wetlands were 0.17 MMT CO<sub>2</sub> Eq. in 2024, predominantly driven by the conversion of forests to palustrine scrub/shrub and palustrine emergent wetlands. Although there was no change in biomass carbon stock losses or DOM carbon stock losses resulting from land-use conversion to coastal wetlands in 2024 relative to 2023, emissions resulting from stock changes in these two carbon pools declined by 67.5 percent and 60.1 percent since 1990, respectively. CO<sub>2</sub> removals in soil carbon stocks declined by 7.6 percent in 2024 relative to 2023, while annual soil carbon sequestration rates declined by 52.4 percent across the time series. Methane emissions from lands converted to coastal wetlands decreased by 3.9 percent relative to 2023 and by 39.3 percent since 1990. See Table 6-31.



**Table 6-31: Net GHG Flux from Carbon Stock Changes in Land Converted to Vegetated Coastal Wetlands (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Cropland Converted to Vegetated Coastal Wetlands</b>	+	+	+	+	+	+	+
Biomass Carbon Stock	+	+	+	+	+	+	+
Soil Carbon Stock	+	+	+	+	+	+	+
<b>Forest Land Converted to Vegetated Coastal Wetlands</b>	0.5	0.5	0.1	0.1	0.1	0.1	0.1
Biomass Carbon Stock	0.6	0.6	0.2	0.2	0.2	0.2	0.2
Dead Organic Matter Carbon Flux	0.1	0.1	+	+	+	+	+
Soil Carbon Stock	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
<b>Grassland Converted to Vegetated Coastal Wetlands</b>	+	+	+	+	+	+	+
Biomass Carbon Stock	+	+	+	+	+	+	+
Soil Carbon Stock	+	+	+	+	+	+	+
<b>Other Land Converted to Vegetated Coastal Wetlands</b>	+	+	+	+	+	+	+
Biomass Carbon Stock	+	+	+	+	+	+	+
Soil Carbon Stock	+	+	+	+	+	+	+
<b>Settlements Converted to Vegetated Coastal Wetlands</b>	+	+	+	+	+	+	+
Biomass Carbon Stock	+	+	+	+	+	+	+
Soil Carbon Stock	+	+	+	+	+	+	+
<b>Total Biomass Flux</b>	0.6	0.6	0.2	0.2	0.2	0.2	0.2
<b>Total Dead Organic Matter Flux</b>	0.1	0.1	+	+	+	+	+
<b>Total Soil Carbon Flux</b>	(0.3)	(0.3)	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)
<b>Total Carbon Flux</b>	0.5	0.5	0.1	0.1	0.1	0.1	0.1
<b>Total CH<sub>4</sub> Emissions from Land Converted to Coastal Wetlands</b>	0.3	0.3	0.2	0.2	0.2	0.2	0.2
<b>Total Net Flux</b>	0.7	0.7	0.3	0.3	0.3	0.3	0.3

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). To determine coastal wetland areas and conversion of lands from other land uses to coastal wetlands, the most recent release of the C-CAP data product containing 2021 land cover estimates was used as the key activity data for the coastal wetland estimates was integrated into emissions calculations for this *GHGIA* (NOAA, 2024b). Coastal wetland areas were derived from 30-meter resolution C-CAP land cover data products, with coastal areas in the 2016 C-CAP product (NOAA, 2024a) compared to the 2021 C-CAP product to identify land areas that had been converted from other land uses to coastal wetlands over the intervening 5-year period. The same seaward and inland geospatial boundaries used to define coastal wetlands in EPA (2025) were applied to the 2021 C-CAP product to isolate coastal wetlands that meet the land-use definition for the purposes of this *GHGIA* consistently across the time series.

To extend the time series back to 1990 and forecast land cover estimates through 2024, annualized changes in vegetated coastal wetland remaining vegetated coastal wetlands, conversions of land from other land uses to coastal wetlands consistent with the closest date of available C-CAP product were applied to each remaining year of the time series. This extrapolation technique mirrors the technique applied in EPA (2025) to fill activity data gaps for years of the time series for which C-CAP data are unavailable.

## Recalculations

In this *GHGIA*, 2021 C-CAP land cover estimates were integrated into estimates, replacing coastal wetland areas from 2017 to 2023 that had been extrapolated from the 2016 C-CAP land cover product (NOAA, 2024a). This resulted in a recalculation of lands converted to coastal wetlands ecosystem carbon flux estimates as well as CH<sub>4</sub> emission estimates from lands converted to coastal wetlands. Across the 2021-2023 recalculation time series, the average annual impact of this recalculation on lands converted to coastal wetlands biomass flux estimates was a 58.7 percent (0.073 MMT CO<sub>2</sub> Eq.) increase in emissions, the impact on soil carbon fluxes was a 0.7 percent (0.001 MMT CO<sub>2</sub> Eq.) increase in removals, and the impact on DOM carbon fluxes was a 53.6 percent (0.015 MMT CO<sub>2</sub> Eq.) increase in emissions. Finally, the impact of this recalculation on CH<sub>4</sub> emissions in lands converted to coastal wetlands was an average annual increase in emissions of 4.7 percent (0.008 MMT CO<sub>2</sub> Eq.) across the 2017-2023 recalculation period.

## Uncertainty

Alongside the factors contributing to uncertainty in emissions and removals estimates listed in the coastal wetlands remaining coastal wetlands emissions section of this *GHGIA*, additional uncertainty is contributed by the use of default carbon stock factors (IPCC, 2006, 2013) that are used to estimate carbon stocks occurring on converted lands prior to conversion to coastal wetlands.

For this current *GHGIA*, the overall uncertainty in lands converted to coastal wetlands emissions and removals estimates is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources in this *GHGIA*. Previous uncertainty estimates reported by EPA (2025) were calculated using the 2006 IPCC Guidelines Approach 1: Error Propagation methodology (IPCC, 2006). The *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025) presents upper and lower bounds defining the 95% confidence interval, with a range

of approximately 42.2 percent below and 42.2 percent above reported emissions estimates for total emissions in 2024, including carbon fluxes in biomass, soil, and DOM pools as well as CH<sub>4</sub> emissions estimates. Additional uncertainty information for individual carbon pool fluxes and gases associated with 2024 emissions and removals is available at the end of this chapter in Table 6-45.

## Land Converted to Flooded Lands

Land converted to flooded lands includes those lands converted to flooded land waterbodies such as reservoirs. As discussed in the flooded land remaining flooded land category, CH<sub>4</sub>, CO<sub>2</sub>, and N<sub>2</sub>O are produced in flooded land waterbodies through the natural breakdown of organic matter; however, N<sub>2</sub>O emissions are included in other categories.

In 2024, total CH<sub>4</sub> emissions from land converted to flooded land (including both reservoirs and freshwater ponds) were 0.2 MMT CO<sub>2</sub> Eq., while total CO<sub>2</sub> emissions were 0.3 MMT CO<sub>2</sub> Eq., as shown in Tables 6-32 through 6-37. Consistent with the trend discussed in flooded land remaining flooded land, there has been a decrease in emissions from land converted flooded land as waterbodies have transitioned from land converted to flooded land into the flooded land remaining flooded land.

**Table 6-32: CH<sub>4</sub> Emissions from Land Converted to Flooded Land–Reservoirs (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
<b>Reservoirs</b>							
Surface Emissions	2.4	0.4	0.2	0.2	0.2	0.2	0.2
Downstream Emissions	0.2	+	+	+	+	+	+
<b>Total</b>	<b>2.6</b>	<b>0.5</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding.

**Table 6-33: CO<sub>2</sub> Emissions from Land Converted to Flooded Land–Reservoirs (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
Reservoirs	3.2	0.6	0.3	0.3	0.3	0.3	0.3

**Table 6-34: Methane and CO<sub>2</sub> Emissions from Reservoirs in Land Converted to Flooded Land in 2024 (kt CH<sub>4</sub>; kt CO<sub>2</sub>)**

State	CH <sub>4</sub>			CO <sub>2</sub>
	Surface	Downstream	Total	Surface
Alabama	+	+	+	+
Alaska	+	+	+	+
Arizona	+	+	+	+
Arkansas	+	+	+	+
California	+	+	+	+
Colorado	+	+	+	1.3
Connecticut	+	+	+	+
Delaware	+	+	+	+
District of Columbia	+	+	+	+
Florida	+	+	+	7.5
Georgia	+	+	+	0.8
Hawaii	+	+	+	+
Idaho	+	+	+	1.5
Illinois	+	+	+	4.1
Indiana	+	+	+	+
Iowa	+	+	+	0.7
Kansas	+	+	+	+
Kentucky	+	+	+	+
Louisiana	+	+	+	+
Maine	+	+	+	+
Maryland	+	+	+	+
Massachusetts	+	+	+	4.3
Michigan	+	+	+	+
Minnesota	4.6	+	5.0	203.2
Mississippi	+	+	+	+
Missouri	+	+	+	+
Montana	+	+	+	+

*(continued)*

**Table 6-34: Methane and CO<sub>2</sub> Emissions from Reservoirs in Land Converted to Flooded Land in 2024 (kt CH<sub>4</sub>; kt CO<sub>2</sub>) (continued)**

State	CH <sub>4</sub>			CO <sub>2</sub>
	Surface	Downstream	Total	Surface
Nebraska	+	+	+	0.9
Nevada	+	+	+	+
New Hampshire	+	+	+	+
New Jersey	+	+	+	+
New Mexico	+	+	+	0.7
New York	+	+	+	+
North Carolina	+	+	+	1.8
North Dakota	0.5	+	0.5	22.2
Ohio	+	+	+	+
Oklahoma	+	+	+	+
Oregon	+	+	+	+
Pennsylvania	+	+	+	0.5
Puerto Rico	+	+	+	+
Rhode Island	+	+	+	+
South Carolina	+	+	+	+
South Dakota	+	+	+	+
Tennessee	+	+	+	+
Texas	+	+	+	+
Utah	+	+	+	0.8
Vermont	+	+	+	+
Virginia	+	+	+	+
Washington	+	+	+	+
West Virginia	+	+	+	+
Wisconsin	+	+	+	+
Wyoming	+	+	+	0.5

+ Does not exceed 0.05 kt.

**Table 6-35: CH<sub>4</sub> Emissions from Land Converted to Flooded Land—Other Constructed Waterbodies (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
Freshwater Ponds	0.1	+	+	+	+	+	+

+ Does not exceed 0.05 MMT CO<sub>2</sub> Eq.

**Table 6-36: CO<sub>2</sub> Emissions from Land Converted to Flooded Land—Other Constructed Waterbodies (MMT CO<sub>2</sub> Eq.)**

Source	1990	2005	2020	2021	2022	2023	2024
Freshwater Ponds	0.1	+	+	+	+	+	+

+ Does not exceed 0.05 MMT CO<sub>2</sub> Eq.

**Table 6-37: Methane and CO<sub>2</sub> Emissions from Other Constructed Waterbodies in Land Converted to Flooded Land in 2024 (MT CO<sub>2</sub> Eq.)**

State	Freshwater Ponds		
	CH <sub>4</sub>	CO <sub>2</sub>	Total
Alabama	1	1	1
Alaska	+	+	+
Arizona	+	+	+
Arkansas	1	1	3
California	27	32	59
Colorado	224	177	401
Connecticut	+	+	1
Delaware	+	+	1
District of Columbia	+	+	+
Florida	+	+	+
Georgia	247	445	693
Hawaii	+	+	+
Idaho	4	5	9
Illinois	73	63	136
Indiana	+	+	+

(continued)

**Table 6-37: Methane and CO<sub>2</sub> Emissions from Other Constructed Waterbodies in Land Converted to Flooded Land in 2024 (MT CO<sub>2</sub> Eq.) (continued)**

State	Freshwater Ponds		
	CH <sub>4</sub>	CO <sub>2</sub>	Total
Iowa	224	214	438
Kansas	274	287	561
Kentucky	13	13	26
Louisiana	17	34	50
Maine	1	1	2
Maryland	44	46	90
Massachusetts	289	264	553
Michigan	48	35	84
Minnesota	170	124	294
Mississippi	339	525	864
Missouri	112	117	229
Montana	69	50	119
Nebraska	352	310	662
Nevada	83	65	148
New Hampshire	90	66	156
New Jersey	+	+	+
New Mexico	58	59	117
New York	46	34	80
North Carolina	141	147	288
North Dakota	207	151	358
Ohio	172	163	335
Oklahoma	219	239	458
Oregon	+	+	1
Pennsylvania	20	19	39
Puerto Rico	+	+	+

(continued)

**Table 6-37: Methane and CO<sub>2</sub> Emissions from Other Constructed Waterbodies in Land Converted to Flooded Land in 2024 (MT CO<sub>2</sub> Eq.) (continued)**

State	Freshwater Ponds		
	CH <sub>4</sub>	CO <sub>2</sub>	Total
Rhode Island	+	+	+
South Carolina	47	49	95
South Dakota	424	310	734
Tennessee	10	11	21
Texas	85	145	230
Utah	51	38	89
Vermont	16	11	27
Virginia	11	12	23
Washington	90	87	177
West Virginia	109	114	223
Wisconsin	55	40	96
Wyoming	130	95	225
<b>Total</b>	<b>4,594</b>	<b>4,600</b>	<b>9,194</b>

+ Does not exceed 0.5 kt CH<sub>4</sub>.

Note: Totals may not sum due to independent rounding.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). The flooded lands analysis was updated to matriculate existing waterbodies in land converted to flooded land (e.g., dams, reservoirs, ponds) to flooded land remaining flooded land flooded lands based on age, consistent with the 20-year transition approach per IPCC guidance (see Tables 6-38 and 6-39). This is reflected in the state-level surface area tables below. No new data from NWI, NHD, NID, or other activity data were incorporated.

**Table 6-38: State Breakdown of Surface Area in Land Converted to Flooded Land–Reservoirs (thousands of ha)**

State	1990	2005	2020	2021	2022	2023	2024
Alabama	8.6	0.1	+	+	+	+	+
Alaska	0.6	+	+	+	+	+	+
Arizona	0.1	0.1	+	+	+	+	+
Arkansas	33.5	2.9	+	+	+	+	+
California	15.7	1.8	0.1	0.1	0.1	0.1	0.1
Colorado	7.4	1.3	0.4	0.4	0.4	0.4	0.3
Connecticut	1.2	1.1	+	+	+	+	+
Delaware	+	+	+	+	+	+	+
District of Columbia	+	+	+	+	+	+	+
Florida	10.1	3.2	1.5	1.3	1.3	1.3	0.7
Georgia	15.6	0.0	0.1	0.1	0.1	0.1	0.1
Hawaii	+	+	+	+	+	+	+
Idaho	17.8	1.0	0.4	0.4	0.4	0.4	0.4
Illinois	49.3	39.2	1.3	0.8	0.8	0.8	0.8
Indiana	9.8	0.2	+	+	+	+	+
Iowa	9.5	2.2	0.5	0.5	0.4	0.4	0.1
Kansas	9.7	0.4	0.1	0.1	+	+	+
Kentucky	3.8	0.1	+	+	+	+	+
Louisiana	8.8	3.0	0.9	+	+	+	+
Maine	11.4	4.5	+	+	+	+	+
Maryland	0.6	+	+	+	+	+	+
Massachusetts	1.4	0.2	1.0	1.0	1.0	1.0	1.0
Michigan	11.9	1.0	0.1	0.1	0.1	0.1	0.1

*(continued)*

**Table 6-38: State Breakdown of Surface Area in Land Converted to Flooded Land—Reservoirs (thousands of ha) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Minnesota	8.1	5.1	53.8	53.7	53.5	54.3	54.3
Mississippi	5.2	2.5	0.1	0.1	0.1	0.1	0.1
Missouri	16.3	0.1	+	+	+	+	+
Montana	14.3	3.9	2.1	2.1	2.1	+	+
Nebraska	5.4	1.3	0.2	0.2	0.2	0.2	0.2
Nevada	1.3	1.1	0.1	0.1	0.1	0.1	0.1
New Hampshire	0.4	+	+	+	+	+	+
New Jersey	0.6	0.5	+	+	+	+	+
New Mexico	3.6	1.5	0.2	0.2	0.2	0.1	0.1
New York	13.9	12.0	0.1	0.1	0.1	0.1	0.1
North Carolina	11.6	0.3	0.4	0.4	0.4	0.4	0.3
North Dakota	1.9	3.5	6.4	6.3	6.0	6.0	5.9
Ohio	6.6	0.5	0.2	0.2	0.1	0.1	0.1
Oklahoma	34.0	6.8	+	+	+	+	+
Oregon	9.7	0.3	0.2	0.1	0.1	0.0	0.0
Pennsylvania	6.9	0.3	0.1	0.1	0.1	0.1	0.1
Puerto Rico	+	+	+	+	+	+	+
Rhode Island	0.1	+	+	+	+	+	+
South Carolina	17.7	9.5	+	+	+	+	+
South Dakota	0.6	3.9	+	+	+	+	+
Tennessee	58.5	0.0	0.1	0.1	0.1	0.1	0.1
Texas	72.3	0.5	+	+	+	+	+
Utah	1.8	0.1	0.2	0.2	0.2	0.2	0.2
Vermont	0.2	0.1	+	+	+	+	+

(continued)

**Table 6-38: State Breakdown of Surface Area in Land Converted to Flooded Land–Reservoirs (thousands of ha) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Virginia	6.6	0.2	+	+	+	+	+
Washington	5.6	1.1	+	+	+	+	+
West Virginia	3.4	1.6	0.2	0.2	0.1	0.1	0.1
Wisconsin	1.9	0.3	0.1	0.1	0.1	0.1	0.1
Wyoming	14.6	5.2	0.2	0.2	0.2	0.1	0.1
<b>Total</b>	<b>549.9</b>	<b>124.7</b>	<b>71.2</b>	<b>69.3</b>	<b>68.4</b>	<b>66.9</b>	<b>65.7</b>

+ Does not exceed 0.05 kha.

Note: Totals may not sum due to independent rounding.

**Table 6-39: State Breakdown of Surface Area in Land Converted to Flooded Land–Freshwater Ponds (hectares)**

State	1990	2005	2020	2021	2022	2023	2024
Alabama	381	24	1	1	+	+	+
Alaska	6	+	+	+	+	+	+
Arizona	41	13	+	+	+	+	+
Arkansas	336	2	+	+	+	+	+
California	226	90	20	20	14	7	5
Colorado	225	49	56	56	56	53	44
Connecticut	74	5	+	+	+	+	+
Delaware	4	+	+	+	+	+	+
District of Columbia	+	+	+	+	+	+	+
Florida	100	41	11	5	3	3	+
Georgia	1,690	86	51	51	51	51	48
Hawaii	7	2	+	+	+	+	+
Idaho	101	1	1	1	1	1	1
Illinois	539	102	20	18	15	14	14
Indiana	469	98	22	22	12	6	0
Iowa	2,328	1,460	189	96	66	57	44
Kansas	2,252	162	99	78	82	72	53
Kentucky	375	35	3	3	3	3	3
Louisiana	130	25	12	12	12	11	3
Maine	29	9	+	+	+	+	+
Maryland	214	64	13	11	10	9	9
Massachusetts	57	68	66	65	61	60	56
Michigan	149	51	9	9	9	9	9
Minnesota	275	96	50	42	34	34	33
Mississippi	348	165	92	86	78	69	66
Missouri	3,363	169	52	45	41	35	22
Montana	359	106	99	99	99	13	13

(continued)

**Table 6-39: State Breakdown of Surface Area in Land Converted to Flooded Land–Freshwater Ponds (hectares) (continued)**

State	1990	2005	2020	2021	2022	2023	2024
Nebraska	1,272	274	100	91	88	79	69
Nevada	17	51	28	23	21	16	16
New Hampshire	140	45	18	18	18	18	18
New Jersey	35	14	+	+	+	+	+
New Mexico	24	34	20	17	13	11	11
New York	304	130	25	20	20	9	9
North Carolina	482	90	30	28	28	28	28
North Dakota	149	160	66	58	55	44	40
Ohio	411	265	67	55	53	36	33
Oklahoma	1,923	144	79	73	64	62	43
Oregon	179	64	17	16	16	16	0
Pennsylvania	247	39	4	4	4	4	4
Puerto Rico	+	+	+	+	+	+	+
Rhode Island	9	7	+	+	+	+	+
South Carolina	756	234	9	9	9	9	9
South Dakota	285	114	113	105	105	90	83
Tennessee	406	46	3	3	3	3	2
Texas	2,738	107	26	25	25	18	17
Utah	85	21	20	20	20	10	10
Vermont	72	11	3	3	3	3	3
Virginia	58	4	2	2	2	2	2
Washington	146	46	20	20	19	18	18
West Virginia	121	47	28	28	28	28	21
Wisconsin	149	19	21	21	21	21	11
Wyoming	277	150	78	75	72	34	25
<b>Total</b>	<b>24,363</b>	<b>5,037</b>	<b>1,645</b>	<b>1,435</b>	<b>1,333</b>	<b>1,066</b>	<b>897</b>

+ Does not exceed 0.05 ha.

Note: Totals may not sum due to independent rounding.



## Recalculations

No recalculations were implemented for this current *GHGIA*.

## Uncertainty

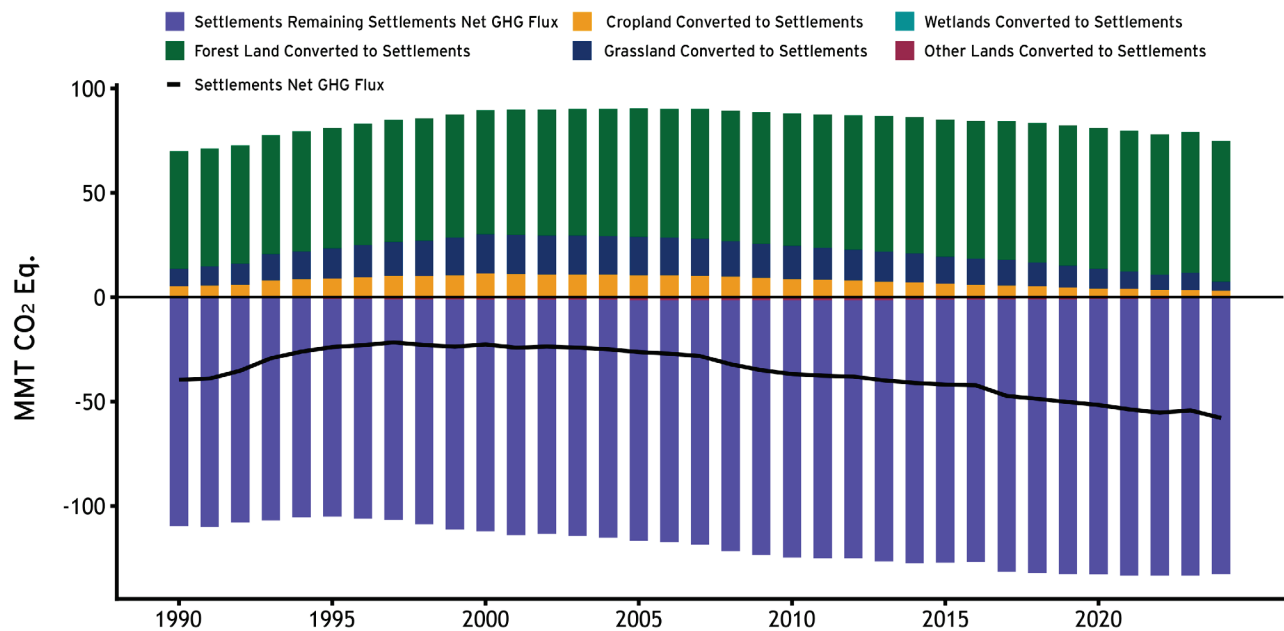
Uncertainty stems from the spatial data (area estimates) from the underlying activity data (e.g., NHD, NWI, and NID). For this current *GHGIA*, the overall uncertainty of CH<sub>4</sub> and CO<sub>2</sub> emissions from flooded land remaining flooded land is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). The EPA (2025) confidence level indicates a range of approximately 13.1 percent below and 12.7 percent above total (CH<sub>4</sub> and CO<sub>2</sub>, MMT CO<sub>2</sub> Eq.) reservoir emissions and 1.4 percent below and 1.2 percent above the other constructed waterbodies emissions estimate. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.6 Settlements

This land-use category includes all developed land, including transportation infrastructure and human settlements (residential, industrial, and commercial land) (IPCC, 2006), consistent with EPA (2025) definitions. The definition of settlements is based on USDA NRI. Figure 6-6 depicts the total emissions and removals contributions occurring on all settlement areas, including settlements remaining settlements and lands converted from each individual land-use category to settlements.

**Figure 6-6: Trends in Emissions and Removals from Settlements**



Note: The “Settlements Remaining Settlements Net GHG Flux” bar reflects the net carbon flux in settlement trees, net carbon flux in landfilled yard trimmings and food scraps, net soil carbon flux in settlements remaining settlements, and N<sub>2</sub>O emissions from all settlement soils. Each land converted to settlement category/bar includes estimates of annual net changes in all ecosystem carbon stocks. The “Settlements Net GHG Flux” line reflects the combined total of all emissions and removals occurring across settlements remaining settlements and all land converted to settlements categories.

### 6.6.1 Settlements Remaining Settlements (Source Category 4E1)

Emissions and removals reported in the settlements remaining settlements category include:

- Soil Carbon Stock Changes - CO<sub>2</sub> Emissions from Drained Organic Soils (CO<sub>2</sub>)
- Changes in Carbon Stocks in Settlement Trees (CO<sub>2</sub>)
- N<sub>2</sub>O Emissions from Settlement Soils (N<sub>2</sub>O)

- Carbon Stock Changes in Landfilled Yard Trimmings and Food Scraps (CO<sub>2</sub>)

## Soil Carbon Stock Changes

Settlements remaining settlements includes carbon stock change estimates from the management of soils in developed areas, primarily from the drainage of organic soils. This *GHGIA* only estimates soil carbon stock changes from organic soils, consistent with IPCC Tier 1 method.

In 2024, CO<sub>2</sub> emissions from drained organic soils in settlements were 16.7 MMT CO<sub>2</sub> Eq. (4.6 MMT carbon), as shown in Table 6-40. Since 1990, emissions have increased by 69 percent due to an increase in area of drained organic soils in settlements, often to support infrastructure development.

**Table 6-40: Net CO<sub>2</sub> Flux from Soil Carbon Stock Changes in Settlements Remaining Settlements (MMT CO<sub>2</sub> Eq.)**

Soil Type	1990	2005	2020	2021	2022	2023	2024
Organic Soils	9.9	10.1	15.1	15.4	15.8	16.3	16.7

### Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Areas of drained organic soils in settlements were not compiled for this analysis. A linear regression model with ARIMA errors was used to forecast the net CO<sub>2</sub> flux from soil carbon stock changes in settlements remaining settlements from 2021 to 2024, as described in Box 5-1.

### Recalculations

Using the updated forecasting approach resulted in recalculations to the 2021 to 2023 time series. These recalculations result in annual changes of approximately 0.2 MMT CO<sub>2</sub> Eq. (–1.2 percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). There were no recalculations to estimates from 1990 to 2020.

### Uncertainty

For this current *GHGIA*, the overall uncertainty of CO<sub>2</sub> emissions from drained organic soils in settlements remaining settlements is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 59 percent below and 59 percent above the estimate of CO<sub>2</sub> emissions from drained organic soils in settlements remaining settlements. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Changes in Carbon Stocks in Settlement Trees

Settlement trees include estimates of carbon stock changes from trees in settlement areas. Total carbon stock change estimates are impacted by settlement area, urban forest management, and other tree cover changes. Estimates include net flux from trees in both settlements remaining settlements and lands converted to settlements.

In 2024, net carbon sequestration from settlement trees was estimated to be 139.9 MMT CO<sub>2</sub> Eq. (see Table 6-41). Across the 1990-2024 time series, settlement trees sequestered an annual net average of 119.3 MMT CO<sub>2</sub> Eq. Driven by increases in settlement areas and tree cover, sequestration has increased 45 percent since 1990.

**Table 6-41: Net Flux from Trees in Settlements Remaining Settlements (MMT CO<sub>2</sub> Eq. and MMT Carbon)**

Year	1990	2005	2020	2021	2022	2023	2024
MMT CO <sub>2</sub> Eq.	(96.5)	(117.0)	(136.6)	(137.6)	(138.4)	(139.0)	(139.9)
MMT Carbon	(26.3)	(31.9)	(37.3)	(37.5)	(37.7)	(37.9)	(38.2)

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

### Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Percent tree cover by state for 2024 held constant with 2023; area estimates by state were updated to calculate percent settlement tree cover area by state and estimate net CO<sub>2</sub> fluxes.

### Recalculations

No recalculations were implemented for this current *GHGIA*.

### Uncertainty

In general, there is uncertainty associated with settlement area estimates, percent tree cover, and estimates of gross and net sequestration. There is also uncertainty associated with the biomass model used to estimate biomass of subsequent carbon stocks, conversation factors, and tree decomposition assumptions. More details are provided in EPA (2025).

For this current *GHGIA*, the overall uncertainty of net fluxes emissions from settlement trees is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with maintaining canopy cover consistent with 2023, as well as updated settlement area estimates, that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 50 percent below and 52 percent above the settlement trees net flux estimate. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## N<sub>2</sub>O Emissions from Settlement Soils

N<sub>2</sub>O emissions from settlement soils occur from nitrification and denitrification processes in soils within settlement areas. These emissions occur via fertilizer application and other inputs to, for example, residential lawns, parks, and golf courses, resulting in direct and indirect N<sub>2</sub>O emissions.

In 2024, N<sub>2</sub>O emissions from soils in settlements remaining settlements were 2.3 MMT CO<sub>2</sub> Eq., as shown in Table 6-42. Estimates show an overall 9 percent increase from 1990 to 2024, driven primarily by the expansion of settlement areas and the associated rise in synthetic nitrogen fertilizer use, which reached its highest levels between 2006 and 2008. Year-to-year fluctuations in these emissions are attributed to direct application of soil inputs and the area of drained organic soils.

**Table 6-42: N<sub>2</sub>O Emissions from Soils in Settlements Remaining Settlements (MMT CO<sub>2</sub> Eq.)**

N <sub>2</sub> O Emissions from Soils	1990	2005	2020	2021	2022	2023	2024
<b>Direct N<sub>2</sub>O Emissions from Soils</b>	<b>1.7</b>	<b>2.6</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>
Synthetic Fertilizers	0.8	1.5	0.7	0.6	0.6	0.6	0.6
Biosolids	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Drained Organic Soils	0.8	1.0	1.2	1.2	1.2	1.2	1.2
<b>Indirect N<sub>2</sub>O Emissions from Soils</b>	<b>0.3</b>	<b>0.5</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>
<b>Total</b>	<b>2.1</b>	<b>3.1</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>

Note: Totals may not sum due to independent rounding.

### Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025).

A linear regression model with ARIMA errors was used to forecast direct organic soils N<sub>2</sub>O emissions, including the nitrogen fertilizer applied to settlements, for the years 2021 to 2024. Updated sludge data was not available at the time of this analysis, so the 2023 values were held constant for 2024.

### Recalculations

Using the updated forecasting approach resulted in recalculations to the 2021 to 2023 time series. These recalculations resulted in changes ranging from 0.10 MMT CO<sub>2</sub> Eq. (-4.1 percent) to 0.28 MMT CO<sub>2</sub> Eq. (-11.0 percent) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). There were no recalculations to estimates from 1990 to 2020.

## Uncertainty

For this current *GHGIA*, the overall uncertainty of N<sub>2</sub>O emissions from soils in settlements remaining settlements is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 47 percent below and 54 percent above direct N<sub>2</sub>O estimate and approximately 76 percent below and 218 percent above the indirect N<sub>2</sub>O estimate for N<sub>2</sub>O emissions from soils in settlements remaining settlements. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## Changes in Yard Trimmings and Food Scrap Carbon Stocks in Landfills

The carbon contained in landfilled yard trimmings and food scraps, which make up a significant portion of the municipal waste stream, can be stored for very long periods of time.

In 2024, the net change in landfilled yard trimmings and food scrap carbon stocks was 11.0 MMT CO<sub>2</sub> Eq. (3.0 MMT carbon). Since 1990, total net flux of carbon stocks has decreased (less sequestration) by approximately 55 percent (see Table 6-43). Over this time period, there has been an increase in food scrap disposal in landfills and a decrease of disposal of yard trimmings landfills.

**Table 6-43: Net Changes in Yard Trimmings and Food Scrap Carbon Stocks in Landfills (MMT CO<sub>2</sub> Eq.)**

Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Yard Trimmings</b>	(20.1)	(7.5)	(8.2)	(8.2)	(8.2)	(8.2)	(8.2)
Grass	(1.7)	(0.6)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Leaves	(8.7)	(3.4)	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)
Branches	(9.8)	(3.4)	(3.7)	(3.7)	(3.6)	(3.6)	(3.6)
<b>Food Scraps</b>	(4.4)	(3.9)	(4.5)	(4.3)	(4.1)	(3.9)	(2.8)
<b>Total Net Flux</b>	(24.5)	(11.4)	(12.8)	(12.5)	(12.3)	(12.1)	(11.0)

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2023* (EPA, 2025). Updated activity data has been identified but further investigation is needed before

incorporating into this analysis. As a result, no new activity data were used; the data from 2023 was held constant for 2024.

## Recalculations

No recalculations were implemented for this current *GHGIA*.

## Uncertainty

The uncertainty of landfilled yard trimmings and food scraps estimates comes from uncertainty of the underlying data and factors including data on total landfill disposal, initial carbon content, moisture content, decay rate, and proportion of carbon stored (EPA, 2025). There is also uncertainty associated with the proportion of disposed materials between the various pools and subpools (e.g., branches versus leaves).

For this current *GHGIA*, the overall uncertainty of landfilled yard trimmings and food scraps is assumed to be similar to EPA (2025) given the use of the same underlying methodology and data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). The EPA (2025) confidence level indicates a range of approximately 57 percent below and 56 percent above net flux estimates of carbon stocks from landfilled yard trimmings and food scraps. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.

## 6.6.2 Land Converted to Settlements (Source Category 4E2)

Land converted to settlements includes carbon stock changes resulting from conversion of other lands to developed uses. Forest land converted to settlements, in particular, can lead to large losses of carbon. Long-term trends in losses of carbon reflect patterns of urban expansion and infrastructure development.

In 2024, the total net flux from land converted to settlements was 74.1 MMT CO<sub>2</sub> Eq., a 6.6 percent increase in CO<sub>2</sub> emissions compared to 1990 (see Table 6-44). Seventy-five percent of the average total loss of carbon comes from forest land conversion, leading to large losses of aboveground biomass, in particular, and other carbon pools.



**Table 6-44: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter and Biomass Carbon Stock Changes for Land Converted to Settlements (MMT CO<sub>2</sub> Eq.)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
<b>Cropland Converted to Settlements</b>	<b>5.3</b>	<b>9.9</b>	<b>4.0</b>	<b>3.7</b>	<b>3.4</b>	<b>3.2</b>	<b>3.0</b>
Total Live Biomass	2.6	1.7	1.0	1.0	1.0	1.1	1.1
Mineral Soils	2.1	6.9	2.6	2.3	2.0	1.8	1.7
Organic Soils	0.5	1.2	0.4	0.4	0.3	0.3	0.2
<b>Forest Land Converted to Settlements</b>	<b>56.1</b>	<b>61.4</b>	<b>67.4</b>	<b>67.4</b>	<b>67.4</b>	<b>67.4</b>	<b>67.4</b>
Aboveground Live Biomass	32.5	35.2	38.7	38.7	38.7	38.7	38.7
Belowground Live Biomass	5.6	6.1	6.7	6.7	6.7	6.7	6.7
Dead Wood	9.1	9.9	10.9	10.9	10.9	10.9	10.9
Litter	7.8	8.5	9.4	9.4	9.4	9.4	9.4
Mineral Soils	1.0	1.5	1.5	1.5	1.5	1.5	1.5
Organic Soils	0.1	0.2	0.3	0.2	0.2	0.2	0.2
<b>Grassland Converted to Settlements</b>	<b>8.5</b>	<b>18.4</b>	<b>9.6</b>	<b>8.3</b>	<b>7.1</b>	<b>8.4</b>	<b>4.3</b>
Other Grassland Conversion Total Live Biomass <sup>1</sup>	2.9	2.7	1.6	1.7	1.7	1.7	1.7
Woodland Conversion Aboveground Live Biomass	0.4	0.4	0.5	0.5	0.5	0.5	0.5
Woodland Conversion Belowground Live Biomass	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dead Wood	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Litter	0.2	0.2	0.2	0.2	0.2	2.9	0.2
Mineral Soils	4.3	13.7	6.5	5.3	4.1	2.9	1.5
Organic Soils	0.5	1.3	0.5	0.4	0.4	0.3	0.2
<b>Other Lands Converted to Settlements</b>	<b>(0.4)</b>	<b>(1.4)</b>	<b>(0.8)</b>	<b>(0.9)</b>	<b>(0.8)</b>	<b>(0.7)</b>	<b>(0.7)</b>
Mineral Soils	(0.4)	(1.5)	(0.9)	(0.9)	(0.8)	(0.7)	(0.7)
Organic Soils	+	0.1	+	+	+	+	+

(continued)

**Table 6-44: Net CO<sub>2</sub> Flux from Soil, Dead Organic Matter and Biomass Carbon Stock Changes for Land Converted to Settlements (MMT CO<sub>2</sub> Eq.) (continued)**

Land Use/Carbon Pool	1990	2005	2020	2021	2022	2023	2024
Wetlands Converted to Settlements	+	0.6	0.1	0.2	0.2	0.1	0.1
Mineral Soils	+	0.1	+	+	+	+	+
Organic Soils	+	0.6	+	0.2	0.1	0.1	0.1
<b>Total Aboveground Biomass Flux</b>	<b>38.4</b>	<b>40.0</b>	<b>41.8</b>	<b>41.9</b>	<b>41.9</b>	<b>42.0</b>	<b>42.0</b>
<b>Total Belowground Biomass Flux</b>	<b>5.7</b>	<b>6.2</b>	<b>6.8</b>	<b>6.8</b>	<b>6.8</b>	<b>6.8</b>	<b>6.8</b>
<b>Total Dead Wood Flux</b>	<b>9.2</b>	<b>10.1</b>	<b>11.1</b>	<b>11.1</b>	<b>11.1</b>	<b>11.1</b>	<b>11.1</b>
<b>Total Litter Flux</b>	<b>8.0</b>	<b>8.7</b>	<b>9.6</b>	<b>9.6</b>	<b>9.6</b>	<b>12.2</b>	<b>9.6</b>
<b>Total Mineral Soil Flux</b>	<b>7.0</b>	<b>20.7</b>	<b>9.8</b>	<b>8.2</b>	<b>6.8</b>	<b>5.4</b>	<b>4.0</b>
<b>Total Organic Soil Flux</b>	<b>1.2</b>	<b>3.4</b>	<b>1.3</b>	<b>1.3</b>	<b>1.1</b>	<b>0.9</b>	<b>0.7</b>
<b>Total Net Flux</b>	<b>69.5</b>	<b>89.0</b>	<b>80.3</b>	<b>78.8</b>	<b>77.3</b>	<b>78.4</b>	<b>74.1</b>

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or net sequestration.

## Methods

Methods are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

A linear regression model with ARIMA errors was used to forecast soil carbon stock changes (non-federal land mineral soils, federal land mineral soils, and organic soils) from land converted to settlements emissions from 2021 to 2024. Biomass carbon losses from the cropland converted to settlements, grassland converted to settlements, and forest land converted to settlements held constant with 2023 levels.

## Recalculations

Using the updated forecasting approach resulted in recalculations to the 2021 to 2023 time series. These recalculations resulted in changes ranging from 0.9 MMT CO<sub>2</sub> Eq. (1 percent difference) to 2.5 MMT CO<sub>2</sub> Eq. (3 percent difference) compared to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). There were no recalculations to estimates from 1990 to 2020.

## Uncertainty

For this current *GHGIA*, the overall uncertainty of the net flux from land converted to settlements is assumed to be similar to EPA (2025) given the use of the same underlying methodology and

data sources that served as the basis for forecasting the end of the time series, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). There will be increased uncertainties associated with the use of the ARIMA forecasting approach that are not currently reflected in the uncertainty estimates below. The EPA (2025) confidence level indicates a range of approximately 36 percent below and 36 percent above the net flux estimate from land converted to settlements. EPA (2025) provided uncertainty estimates for each carbon pool by land use conversion category. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 6-45.



## 6.7 Other Land

### 6.7.1 Other Land Remaining Other Land (Source Category 4F1)

It is currently not possible to estimate CO<sub>2</sub>, CH<sub>4</sub>, or N<sub>2</sub>O fluxes on other land remaining other land at this time. See Section 6.1 for area estimates of other land remaining other land.

### 6.7.2 Land Converted to Other Land (Source Category 4F2)

It is currently not possible to separate CO<sub>2</sub>, CH<sub>4</sub>, or N<sub>2</sub>O fluxes on land converted to other land from fluxes on other land remaining other land at this time. See Section 6.1 for area estimates of land converted to other land.



## 6.8 LULUCF Uncertainty Summary

Table 6-45 shows the uncertainty summary for each LULUCF sector source and sink. A discussion of the uncertainty ranges is included in each source and/or sink category's respective chapter section.

**Table 6-45: LULUCF Uncertainty Summary**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<b>Forest Land Remaining Forest Land</b>						
Forest Ecosystem Carbon Pools	CO <sub>2</sub>	(759.2)	(686.3)	(832.1)	-9.6%	9.6%
Harvested Wood Products	CO <sub>2</sub>	(100.5)	(72.2)	(125.3)	-28.1%	24.7%
<i>Total Forest Stock Changes</i>	<i>CO<sub>2</sub></i>	<i>(859.7)</i>	<i>(782.3)</i>	<i>(936.2)</i>	<i>-9%</i>	<i>8.9%</i>
Non-CO <sub>2</sub> Emissions from Forest Fires	CH <sub>4</sub>	2.5	2.0	3.1	-22%	22%
Non-CO <sub>2</sub> Emissions from Forest Fires	N <sub>2</sub> O	1.9	1.5	2.3	-22%	22%
Direct N <sub>2</sub> O Fluxes from Forest Soils	N <sub>2</sub> O	0.3	+	1.1	-86%	250%
Indirect N <sub>2</sub> O Fluxes from Forest Soils	N <sub>2</sub> O	0.1	+	0.4	-94%	267%
Drained Organic Forest Soils	CH <sub>4</sub>	+	+	+	-69%	82%
Drained Organic Forest Soils	N <sub>2</sub> O	0.1	+	0.1	-118%	132%
<b>Land Converted to Forest Land</b>						
<i>Cropland Converted to Forest Land (CF)</i>	<i>CO<sub>2</sub></i>	<i>(18.0)</i>	<i>(9.4)</i>	<i>(26.7)</i>	<i>-48%</i>	<i>48%</i>
CF Aboveground Biomass	CO <sub>2</sub>	(10.0)	(1.5)	(18.5)	-85%	85%
CF Belowground Biomass	CO <sub>2</sub>	(1.7)	(0.6)	(2.7)	-62%	62%

(continued)



**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
CF Dead Wood	CO <sub>2</sub>	(3.2)	(1.9)	(4.4)	-39%	39%
CF Litter	CO <sub>2</sub>	(3.1)	(2.1)	(4.2)	-34%	34%
CF Mineral Soils	CO <sub>2</sub>	(0.1)	(0.2)	0.1	-207%	207%
<i>Grassland Converted to Forest Land (GF)</i>	<i>CO<sub>2</sub></i>	<i>(38.6)</i>	<i>(36.3)</i>	<i>(41.0)</i>	<i>-6%</i>	<i>6%</i>
GF Aboveground Biomass	CO <sub>2</sub>	(22.0)	(20.6)	(23.3)	-6%	6%
GF Belowground Biomass	CO <sub>2</sub>	(2.7)	(2.5)	(3.0)	-10%	10%
GF Dead Wood	CO <sub>2</sub>	(5.9)	(5.8)	(6.0)	-2%	2%
GF Litter	CO <sub>2</sub>	(8.0)	(7.5)	(8.5)	-6%	6%
GF Mineral Soils	CO <sub>2</sub>	+	(0.2)	0.2	-49,176%	49,176%
<i>Other Lands Converted to Forest Land (OF)</i>	<i>CO<sub>2</sub></i>	<i>(3.9)</i>	<i>(2.2)</i>	<i>(5.5)</i>	<i>-43%</i>	<i>43%</i>
OF Aboveground Biomass	CO <sub>2</sub>	(1.7)	(0.1)	(3.3)	-95%	95%
OF Belowground Biomass	CO <sub>2</sub>	(0.3)	0.1	(0.6)	-123%	123%
OF Dead Wood	CO <sub>2</sub>	(0.8)	(0.3)	(1.2)	-57%	57%
OF Litter	CO <sub>2</sub>	(0.9)	(0.4)	(1.5)	-56%	56%
OF Mineral Soils	CO <sub>2</sub>	(0.2)	(1.0)	0.6	-412%	412%
<i>Settlements Converted to Forest Land (SF)</i>	<i>CO<sub>2</sub></i>	<i>(32.5)</i>	<i>(26.0)</i>	<i>(39.0)</i>	<i>-20%</i>	<i>20%</i>
SF Aboveground Biomass	CO <sub>2</sub>	(18.6)	(12.2)	(24.9)	-34%	34%
SF Belowground Biomass	CO <sub>2</sub>	(3.1)	(1.8)	(4.4)	-42%	42%
SF Dead Wood	CO <sub>2</sub>	(6.2)	(5.0)	(7.4)	-19%	19%
SF Litter	CO <sub>2</sub>	(4.7)	(3.8)	(5.6)	-19%	19%
SF Mineral Soils	CO <sub>2</sub>	+	+	+	-55%	55%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<i>Wetlands Converted to Forest Land (WF)</i>	CO <sub>2</sub>	(7.8)	(7.7)	(8.0)	-2%	2%
WF Aboveground Biomass	CO <sub>2</sub>	(4.1)	(4.0)	(4.3)	-3%	3%
WF Belowground Biomass	CO <sub>2</sub>	(0.7)	(0.7)	(0.8)	-4%	4%
WF Dead Wood	CO <sub>2</sub>	(1.5)	(1.5)	(1.6)	-3%	3%
WF Litter	CO <sub>2</sub>	(1.4)	(1.3)	(1.4)	-4%	4%
WF Mineral Soils	CO <sub>2</sub>	+	+	+	0%	0%
<i>Total LF Aboveground Biomass</i>	CO <sub>2</sub>	(56.3)	(45.6)	(67.0)	-19%	19%
<i>Total LF Belowground Biomass</i>	CO <sub>2</sub>	(8.5)	(6.8)	(10.2)	-20%	20%
<i>Total LF Dead Wood</i>	CO <sub>2</sub>	(17.6)	(15.9)	(19.4)	-10%	10%
<i>Total LF Litter</i>	CO <sub>2</sub>	(18.2)	(16.5)	(19.6)	-9%	8%
<i>Total LF Mineral Soils</i>	CO <sub>2</sub>	(0.3)	(0.2)	(0.4)	-42%	42%
<i>Total Lands Converted to Forest Lands (LF)</i>	CO <sub>2</sub>	(100.9)	(89.8)	(112.0)	-11%	11%
<b>Cropland Remaining Cropland</b>						
Biomass carbon stocks	CO <sub>2</sub>	(0.8)	139.0	(140.6)	-17,828%	17,828%
Mineral soil carbon stocks Tier 3	CO <sub>2</sub>	(45.5)	5.5	(96.5)	-112%	112%
Mineral soil carbon stocks Tier 2	CO <sub>2</sub>	(1.8)	1.2	(4.8)	-166%	166%
Organic soil carbon stocks	CO <sub>2</sub>	30.1	10.5	49.7	-65%	65%
<i>Total Cropland Remaining Cropland</i>	CO <sub>2</sub>	(18.0)	23.2	(59.3)	-229%	229%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<b>Land Converted to Cropland</b>						
<i>Grassland Converted to Cropland Land (GC)</i>	CO <sub>2</sub>	13.4	(13.4)	40.2	-200%	200%
GC Aboveground Biomass	CO <sub>2</sub>	0.3	(34.2)	34.8	-11,309%	11,309%
GC Belowground Biomass	CO <sub>2</sub>	+	+	+	-100%	67%
GC Dead Wood	CO <sub>2</sub>	+	+	0.1	-100%	121%
GC Litter	CO <sub>2</sub>	+	+	0.1	-100%	148%
GC Mineral Soils Tier 3	CO <sub>2</sub>	8.7	(12.9)	30.3	-249%	249%
GC Mineral Soils Tier 2	CO <sub>2</sub>	1.1	0.1	2.0	-87%	87%
GC Organic Soils	CO <sub>2</sub>	2.3	(0.1)	4.8	-105%	105%
<i>Forest Land Converted to Cropland Land (FC)</i>	CO <sub>2</sub>	20.2	4.0	36.3	-80%	80%
FC Aboveground Biomass	CO <sub>2</sub>	11.6	(3.1)	26.4	-127%	127%
FC Belowground Biomass	CO <sub>2</sub>	2.0	(0.6)	4.6	-128%	127%
FC Dead Wood	CO <sub>2</sub>	3.1	(0.8)	6.9	-127%	127%
FC Litter	CO <sub>2</sub>	3.3	(0.9)	7.5	-127%	127%
FC Mineral Soils Tier 2	CO <sub>2</sub>	0.1	+	0.3	-134%	134%
FC Organic Soils	CO <sub>2</sub>	+	(0.1)	0.1	-504%	504%
<i>Other Lands Converted to Cropland (OC)</i>	CO <sub>2</sub>	(1.0)	0.4	(2.4)	-135%	135%
OC Aboveground Biomass	CO <sub>2</sub>	(0.1)	0.4	(0.6)	-564%	564%
OC Mineral Soils Tier 2	CO <sub>2</sub>	(1.0)	0.3	(2.3)	-135%	135%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
OC Organic Soils	CO <sub>2</sub>	+	+	+	0%	0%
<i>Settlements Converted to Cropland (SC)</i>	CO <sub>2</sub>	(0.2)	0.1	(0.5)	-142%	142%
SC Aboveground Biomass	CO <sub>2</sub>	(0.1)	0.2	(0.4)	-306%	306%
SC Mineral Soils Tier 2	CO <sub>2</sub>	(0.2)	+	(0.3)	-77%	77%
SC Organic Soils	CO <sub>2</sub>	+	+	0.1	-152%	152%
<i>Wetlands Converted to Cropland (WC)</i>	CO <sub>2</sub>	0.2	(0.5)	1.0	-320%	320%
WC Aboveground Biomass	CO <sub>2</sub>	(0.1)	0.3	(0.4)	-383%	383%
WC Mineral Soils Tier 2	CO <sub>2</sub>	0.1	(0.1)	0.3	-144%	144%
WC Organic Soils	CO <sub>2</sub>	0.2	(0.4)	0.8	-303%	303%
<i>Total LC Aboveground Biomass</i>	CO <sub>2</sub>	11.7	(11.9)	35.3	-202%	202%
<i>Total LC Belowground Biomass</i>	CO <sub>2</sub>	2.0	(0.5)	4.6	-126%	126%
<i>Total LC Dead Wood</i>	CO <sub>2</sub>	3.1	(0.8)	7.0	-125%	125%
<i>Total LC Litter</i>	CO <sub>2</sub>	3.4	(0.8)	7.6	-125%	126%
<i>Total LC Mineral Soils Tier 3</i>	CO <sub>2</sub>	8.7	(12.9)	30.3	-249%	249%
<i>Total LC Mineral Soils Tier 2</i>	CO <sub>2</sub>	1.1	(0.8)	2.9	-171%	171%
<i>Total LC Organic Soils</i>	CO <sub>2</sub>	2.6	0.1	5.2	-98%	98%
<i>Total Lands Converted to Cropland (LC)</i>	CO <sub>2</sub>	32.6	(1.6)	66.7	-105%	105%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<b>Grassland Remaining Grassland</b>						
Woodland Aboveground live biomass	CO <sub>2</sub>	(1.0)	(0.9)	(1.1)	-12%	10%
Woodland Belowground live biomass	CO <sub>2</sub>	(0.2)	(0.2)	(0.2)	-8%	8%
Woodland Dead wood	CO <sub>2</sub>	2.5	2.2	2.9	-13%	13%
Woodland Litter	CO <sub>2</sub>	0.2	0.2	0.2	-9%	9%
Mineral soils carbon stocks Tier 3	CO <sub>2</sub>	16.2	(106.1)	138.6	-753%	753%
Mineral Soils carbon stocks Tier 2	CO <sub>2</sub>	0.1	(0.2)	0.4	-491%	491%
Mineral soils carbon stocks, Biosolids Tier 2	CO <sub>2</sub>	(1.0)	(0.5)	(1.5)	-50%	50%
Organic soil carbon stocks	CO <sub>2</sub>	5.5	1.0	9.9	-82%	82%
<i>Total Grassland Remaining Grassland carbon stock change</i>	<i>CO<sub>2</sub></i>	<i>22.2</i>	<i>(102.5)</i>	<i>146.9</i>	<i>-561%</i>	<i>561%</i>
Grassland burning	CH <sub>4</sub>	0.4	+	0.8	-100%	120%
Grassland burning	N <sub>2</sub> O	0.3	+	0.7	-100%	120%
<b>Land Converted to Grassland</b>						
<i>Cropland Converted to Grassland (CG)</i>	<i>CO<sub>2</sub></i>	<i>(11.2)</i>	<i>5.6</i>	<i>(27.9)</i>	<i>-150%</i>	<i>150%</i>
CG Aboveground Biomass	CO <sub>2</sub>	(4.4)	11.5	(20.3)	-362%	362%
CG Belowground Biomass	CO <sub>2</sub>	+	+	+	-97%	100%
CG Dead wood	CO <sub>2</sub>	+	+	(0.1)	-95%	100%
CG litter	CO <sub>2</sub>	+	+	(0.1)	-95%	100%
CG Mineral soil Tier 3	CO <sub>2</sub>	(5.6)	3.8	(14.9)	-168%	168%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
CG Mineral soil Tier 2	CO <sub>2</sub>	(1.9)	0.6	(4.3)	-132%	132%
CG Organic soils	CO <sub>2</sub>	0.8	(0.1)	1.6	-113%	113%
<i>Forest Land Converted to Grassland (FG)</i>	<i>CO<sub>2</sub></i>	<i>47.2</i>	<i>14.2</i>	<i>80.3</i>	<i>-70%</i>	<i>70%</i>
FG Aboveground Biomass	CO <sub>2</sub>	30.0	(1.2)	61.3	-104%	104%
FG Belowground Biomass	CO <sub>2</sub>	4.2	(0.2)	8.7	-104%	105%
FG Dead wood	CO <sub>2</sub>	5.1	(0.2)	10.4	-104%	104%
FG litter	CO <sub>2</sub>	7.9	16.1	16.1	104%	104%
FG Mineral soil Tier 2	CO <sub>2</sub>	(0.1)	(0.3)	(0.3)	140%	140%
FG Organic soils	CO <sub>2</sub>	0.1	0.2	0.2	143%	143%
<i>Other Lands Converted to Grassland (OG)</i>	<i>CO<sub>2</sub></i>	<i>(10.5)</i>	<i>(1.6)</i>	<i>(19.3)</i>	<i>-85%</i>	<i>85%</i>
OG Aboveground Biomass	CO <sub>2</sub>	(0.6)	1.2	(2.3)	-313%	313%
OG Belowground Biomass	CO <sub>2</sub>	+	+	+	-100%	100%
OG Dead wood	CO <sub>2</sub>	+	+	(0.1)	-70%	100%
OG litter	CO <sub>2</sub>	(0.1)	+	(0.1)	-59%	47%
OG Mineral soil Tier 2	CO <sub>2</sub>	(9.8)	(2.7)	(17.0)	-73%	73%
OG Organic soils	CO <sub>2</sub>	0.1	(0.1)	0.2	-212%	212%
<i>Settlements Converted to Grassland (SG)</i>	<i>CO<sub>2</sub></i>	<i>(0.9)</i>	<i>+</i>	<i>(1.8)</i>	<i>-97%</i>	<i>96%</i>
SG Aboveground Biomass	CO <sub>2</sub>	(0.3)	0.3	(0.8)	-208%	208%
SG Belowground Biomass	CO <sub>2</sub>	+	+	+	-45%	100%
SG Dead wood	CO <sub>2</sub>	(0.1)	(0.1)	(0.1)	62%	46%

*(continued)*

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
SG litter	CO <sub>2</sub>	(0.1)	(0.1)	(0.1)	55%	61%
SG Mineral soil Tier 2	CO <sub>2</sub>	(0.5)	(0.7)	(0.7)	54%	43%
SG Organic soils	CO <sub>2</sub>	+	+	+	-451%	451%
<i>Wetlands Converted to Grassland (WG)</i>	<i>CO<sub>2</sub></i>	<i>+</i>	<i>0.2</i>	<i>(0.2)</i>	<i>-3,705%</i>	<i>3,705%</i>
WG Aboveground Biomass	CO <sub>2</sub>	(0.2)	0.6	(0.9)	-411%	410%
WG Belowground Biomass	CO <sub>2</sub>	+	+	+	-100%	100%
WG Dead wood	CO <sub>2</sub>	+	+	+	-46%	100%
WG litter	CO <sub>2</sub>	+	+	+	-138%	100%
WG Mineral soil Tier 2	CO <sub>2</sub>	+	+	+	-213%	213%
WG Organic soils	CO <sub>2</sub>	0.2	(0.1)	0.6	-147%	147%
<i>Total LG Aboveground Biomass</i>	<i>CO<sub>2</sub></i>	<i>24.6</i>	<i>(12.3)</i>	<i>61.6</i>	<i>-150%</i>	<i>150%</i>
<i>Total LG Belowground Biomass</i>	<i>CO<sub>2</sub></i>	<i>4.2</i>	<i>(0.3)</i>	<i>8.6</i>	<i>-106%</i>	<i>106%</i>
<i>Total LG Dead Wood</i>	<i>CO<sub>2</sub></i>	<i>4.9</i>	<i>(0.4)</i>	<i>10.2</i>	<i>-108%</i>	<i>108%</i>
<i>Total LG Litter</i>	<i>CO<sub>2</sub></i>	<i>7.7</i>	<i>(0.5)</i>	<i>15.9</i>	<i>-107%</i>	<i>107%</i>
<i>Total LG Mineral Soils Tier 3</i>	<i>CO<sub>2</sub></i>	<i>(5.6)</i>	<i>3.8</i>	<i>(14.9)</i>	<i>-168%</i>	<i>168%</i>
<i>Total LG Mineral Soils Tier 2</i>	<i>CO<sub>2</sub></i>	<i>(12.3)</i>	<i>(4.8)</i>	<i>(19.8)</i>	<i>-61%</i>	<i>61%</i>
<i>Total LG Organic Soils</i>	<i>CO<sub>2</sub></i>	<i>1.2</i>	<i>0.1</i>	<i>2.2</i>	<i>-88%</i>	<i>88%</i>
<i>Total Lands Converted to Grassland (LG)</i>	<i>CO<sub>2</sub></i>	<i>24.7</i>	<i>(26.2)</i>	<i>75.5</i>	<i>-206%</i>	<i>206%</i>

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<b>Wetlands Remaining Wetlands</b>						
Peatlands Remaining Peatlands	CO <sub>2</sub>	0.6	0.5	0.7	-15%	16%
Peatlands Remaining Peatlands	CH <sub>4</sub>	+	+	+	-58%	80%
Peatlands Remaining Peatlands	N <sub>2</sub> O	+	+	+	-53%	54%
<i>Coastal Wetlands Remaining Coastal Wetlands</i>						
Vegetated Coastal Wetlands Remaining Coastal Wetlands, Biomass carbon stock change	CO <sub>2</sub>	1.0	0.7	1.2	-24.1%	24.1%
Vegetated Coastal Wetlands Remaining Coastal Wetlands, soil carbon stock change	CO <sub>2</sub>	(12.0)	(9.9)	(14.2)	-17.7%	17.7%
Vegetated Coastal Wetlands Remaining Coastal Wetlands, CH <sub>4</sub> emissions	CH <sub>4</sub>	3.8	2.7	5.0	-29.9%	29.9%
Vegetated Coastal Wetlands Converted to Unvegetated Coastal Wetlands, Biomass carbon stock change	CO <sub>2</sub>	0.1	0.1	0.1	-24.1%	24.1%
Vegetated Coastal Wetlands Converted to Unvegetated Coastal Wetlands, dead organic matter carbon stock change	CO <sub>2</sub>	+	+	+	-25.8%	25.8%
Vegetated Coastal Wetlands Converted to Unvegetated Coastal Wetlands, soil carbon stock change	CO <sub>2</sub>	2.8	2.4	3.2	-15.0%	15.0%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
Unvegetated Coastal Wetlands Converted to vegetated Coastal Wetlands, Biomass carbon stock change	CO <sub>2</sub>	(0.2)	(0.2)	(0.2)	-20.0%	20.0%
Unvegetated Coastal Wetlands Converted to vegetated Coastal Wetlands, dead organic matter carbon stock change	CO <sub>2</sub>	+	+	+	-25.8%	25.8%
Unvegetated Coastal Wetlands Converted to vegetated Coastal Wetlands, soil carbon stock change	CO <sub>2</sub>	+	+	+	-17.7%	17.7%
Aquaculture Production	N <sub>2</sub> O	0.1	+	0.3	-116%	116%
<i>Flooded Land Remaining Flooded Land</i>						
Reservoirs—surface	CH <sub>4</sub>	27.8	27.3	28.2	-1.7%	1.3%
Reservoirs—downstream	CH <sub>4</sub>	2.3	2.2	2.7	-4.3%	15.7%
Canals and ditches	CH <sub>4</sub>	7.2	6.8	7.6	-6.0%	5.5%
Freshwater ponds	CH <sub>4</sub>	10.4	10.4	10.4	-0.04%	0.04%
<b>Land Converted to Wetlands</b>						
<i>Land Converted to Coastal Wetlands</i>						
Land Converted to vegetated coastal wetlands, biomass C stock flux	CO <sub>2</sub>	0.2	0.2	0.2	-20.0%	20.0%
Land Converted to vegetated coastal wetlands, dead organic matter flux	CO <sub>2</sub>	+	+	0.1	-25.8%	25.8%
Land Converted to vegetated coastal wetlands, soil C stock flux	CO <sub>2</sub>	(0.1)	(0.1)	(0.1)	-17.7%	17.7%

(continued)

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
Land Converted to vegetated coastal wetlands, CH <sub>4</sub> emissions	CH <sub>4</sub>	0.1	0.1	0.2	-29.9%	29.9%
<i>Land Converted to Flooded Land</i>						
Reservoirs—surface	CH <sub>4</sub>	0.2	0.1	0.2	-12.7%	12.9%
Reservoirs—surface	CO <sub>2</sub>	0.3	0.3	0.3	-13.3%	13.6%
Reservoirs—downstream	CH <sub>4</sub>	+	+	0.1	-63.4%	239.6%
Freshwater ponds	CH <sub>4</sub>	+	+	+	-1.6%	1.3%
Freshwater ponds	CO <sub>2</sub>	+	+	+	-1.4%	1.4%
<b>Settlements Remaining Settlements</b>						
Soil carbon stock changes—drained organic soils	CO <sub>2</sub>	16.7	6.9	26.6	-59%	59%
Changes in C stocks in Settlement Trees	CO <sub>2</sub>	(139.9)	(70.0)	(212.7)	-50%	52%
Direct N <sub>2</sub> O emissions from settlement soils	N <sub>2</sub> O	2.0	1.1	3.1	-47%	54%
Indirect N <sub>2</sub> O emissions from settlement soils	N <sub>2</sub> O	0.3	0.1	0.8	-76%	218%
CO <sub>2</sub> Flux from Yard Trimmings and Food Scraps	CO <sub>2</sub>	(11.0)	(4.7)	(17.1)	-57%	56%
<b>Land Converted to Settlements</b>						
<i>Cropland Converted to Settlements (CS)</i>	CO <sub>2</sub>	3.0	(0.3)	6.3	-109%	109%
CS Total biomass	CO <sub>2</sub>	1.1	(2.1)	4.2	-293%	293%
CS Mineral soil carbon stocks	CO <sub>2</sub>	1.7	(0.3)	3.7	-117%	117%
CS organic soil carbon stocks	CO <sub>2</sub>	0.2	(0.1)	0.6	-148%	148%

*(continued)*

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
<i>Forest Land Converted to Settlements (FS)</i>	CO <sub>2</sub>	67.4	41.1	93.7	-39%	39%
FS aboveground biomass carbon stocks	CO <sub>2</sub>	38.7	14.7	62.7	-62%	62%
FS belowground biomass carbon stocks	CO <sub>2</sub>	6.7	2.6	10.9	-62%	62%
FS dead wood	CO <sub>2</sub>	10.9	4.1	17.7	-62%	62%
FS litter	CO <sub>2</sub>	9.4	3.6	15.2	-62%	62%
FS Mineral soil carbon stocks	CO <sub>2</sub>	1.5	1.0	1.9	-28%	28%
FS organic soil carbon stocks	CO <sub>2</sub>	0.2	+	0.5	-115%	115%
<i>Grassland Converted to Settlements (GS)</i>	CO <sub>2</sub>	4.3	1.5	7.1	-66%	66%
Other grassland (non-woodland) total live biomass	CO <sub>2</sub>	1.7	(1.8)	5.3	-208%	208%
Woodland aboveground biomass carbon stocks	CO <sub>2</sub>	0.5	0.2	0.8	-62%	61%
Woodland belowground biomass carbon stocks	CO <sub>2</sub>	0.1	+	0.1	-44%	0%
GS dead wood	CO <sub>2</sub>	0.2	0.1	0.3	-62%	70%
GS litter	CO <sub>2</sub>	0.2	0.1	0.3	-61%	57%
GS mineral soil carbon stocks	CO <sub>2</sub>	1.5	0.3	2.7	-80%	80%
GS organic soil carbon stocks	CO <sub>2</sub>	0.2	(0.1)	0.5	-157%	157%
<i>Other Lands Converted to Settlements (OS)</i>	CO <sub>2</sub>	(0.7)	+	(1.3)	-99%	99%
OS mineral soil carbon stocks	CO <sub>2</sub>	(0.7)	(1.3)	(1.3)	93%	93%

*(continued)*

**Table 6-45: LULUCF Uncertainty Summary (continued)**

Source	Gas	2024 Estimate (MMT CO <sub>2</sub> Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO <sub>2</sub> Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
OS organic soil carbon stocks	CO <sub>2</sub>	+	(0.1)	+	-591%	0%
<i>Wetlands Converted to Settlements (WS)</i>	CO <sub>2</sub>	0.1	(0.6)	0.2	-910%	126%
WS mineral soils carbon stocks	CO <sub>2</sub>	+	+	+	-126%	126%
WS organic soils carbon stocks	CO <sub>2</sub>	0.1	(0.9)	1.0	-1,831%	1,831%
<i>LS aboveground biomass carbon stocks</i>	CO <sub>2</sub>	42.0	17.6	66.3	-58%	58%
<i>LS belowground biomass carbon stocks</i>	CO <sub>2</sub>	6.8	2.6	11.0	-62%	62%
<i>LS dead wood</i>	CO <sub>2</sub>	11.1	4.3	17.9	-61%	61%
<i>LS litter</i>	CO <sub>2</sub>	9.6	3.7	15.4	-61%	61%
<i>LS mineral soil carbon stocks</i>	CO <sub>2</sub>	4.0	1.5	6.5	-62%	62%
<i>LS organic soil carbon stocks</i>	CO <sub>2</sub>	0.7	(4.8)	6.3	-766%	766%
<i>Total Land Converted to Settlements (LS)</i>	CO <sub>2</sub>	74.1	47.4	100.8	-36%	36%

+ Absolute value does not exceed 0.05 MMT CO<sub>2</sub> Eq.

Note: Parentheses indicate negative values or net sequestration.

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