Updated Preliminary 1990 Greenhouse Gas Inventory Baseline and Statewide Greenhouse Gas Inventory for 2007

Technical Support Document

AFOLU Info Draft - 1/31/2018

Prepared for:

HAWAII STATE DEPARTMENT OF HEALTH

Prepared by:

ICF

Acronyms and Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
BOD	Biochemical oxygen demand
CARB	California Air Resources Board
CH_4	Methane
CO_2	Carbon dioxide
DBEDT	Department of Business, Economic Development, and Tourism
DLNR	Department of Land and Natural Resources
DOH	Department of Health
EPA	Environmental Protection Agency
FOD	First order decay
GHG	Greenhouse gas
GWP	Global warming potential
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
MCF	Methane conversion factor
MMT	million metric tons
MSW	Municipal solid waste
N_2O	Nitrous oxide
NOAA-CCAP	National Oceanic and Atmospheric Administration's Coastal Change Analysis Program
NPDES	National Pollutant Discharge Elimination System
ODS	Ozone Depleting Substance
PFC	Perfluorocarbon
SF_6	Sulfur hexafluoride
SIT	State Inventory Tool
UNFCCC	United Nations Framework Convention on Climate Change
VMT	Vehicle miles traveled
VS	Volatile solids
WMS	Waste management system

4. Agriculture, Forestry and Other Land Uses (AFOLU)

This chapter presents GHG emissions from agricultural activities, land use, changes in land use, and land management practices. For the state of Hawaii, emissions from agriculture, forestry, and other land uses (AFOLU) are estimated from the following sources[16] and gases:

- Agriculture
  - Enteric Fermentation (IPCC Source Category 3A1): CH_4
  - Manure Management (IPCC Source Category 3A2): CH_4, N_2O
  - Agricultural Soil Management (IPCC Source Categories 3C4 and 3C5): N_2O
  - Field Burning of Agricultural Residues (IPCC Source Category 3C1b): CH_4, N_2O
  - Urea Application (IPCC Source Category 3C3): CO_2
- Land Use, Land-Use Change, and Forestry
  - Agricultural Soil Carbon (IPCC Source Categories 3B2 and 3B3): CO_2
  - Forest Fires (IPCC Source Category 3C1a): CO_2, CH_4, N_2O
  - Landfilled Yard Trimmings and Food Scraps (IPCC Source Category 3B5a): CO_2
  - Urban Trees (IPCC Source Category 3B5a): CO_2
  - Forest Carbon (IPCC Source Category 3B1a): CO_2

Agricultural activities are categorized as GHG “sources,” which emit GHGs into the atmosphere. Land use, changes in land use, and land management practices may either be “sources” of GHGs or “sinks” of GHGs (sinks remove CO_2 from the atmosphere). In Hawaii, Landfilled Yard Trimmings and Food Scraps, Urban Trees, and Forest Carbon are CO_2 sinks. The remaining AFOLU categories presented in this chapter are sources of GHGs.

Total emissions (excluding sinks) from the AFOLU sector were 1.34 MMT CO_2 Eq. in 1990 and 1.45 MMT CO_2 Eq. in 2007, accounting for 6 percent of total Hawaii emissions in both inventory years. Carbon sinks were -2.85 MMT CO_2 Eq. in 1990 and -3.00 MMT CO_2 Eq. in 2007, while net emissions were -1.52 MMT CO_2 Eq. in 1990 and -1.55 MMT CO_2 Eq. in 2007. Therefore, the AFOLU sector is a net sink of GHG emissions in Hawaii in both years. Figure 15 and Figure 16 show AFOLU emissions by source for 1990 and 2007. Emission sources and sinks by category and year are summarized in Table 16.

[16] IPCC Source Categories for which emissions were not estimated for the state of Hawaii include: Land Converted to Forest Land (3B1b), Biomass Burning in Grassland (3C1c), Biomass Burning in All Other Land (3C1d), Wetlands (3B4), Other Land (3B6), Liming (3C2), and Harvested Wood Products (3D1). Appendix B provides information on why emissions were not estimated for these IPCC source categories.

Figure 15: 1990 AFOLU Emissions by Source (MMT CO_2 Eq.)

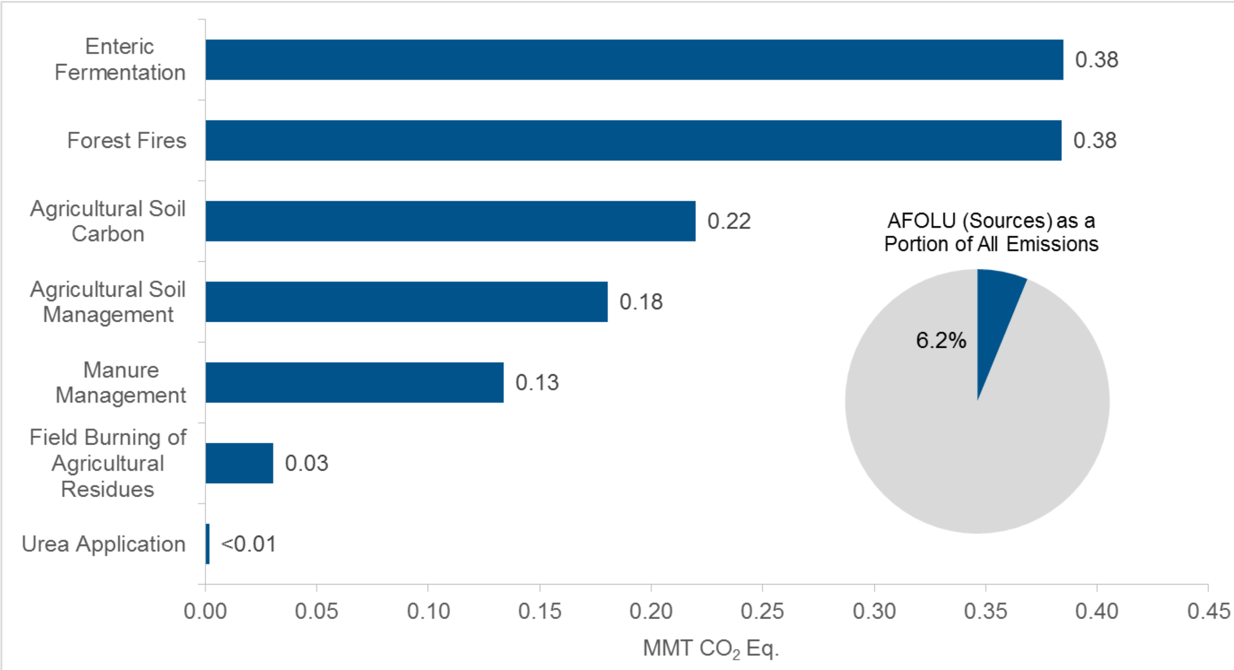


Figure 16: 2007 AFOLU Emissions by Source (MMT CO_2 Eq.)

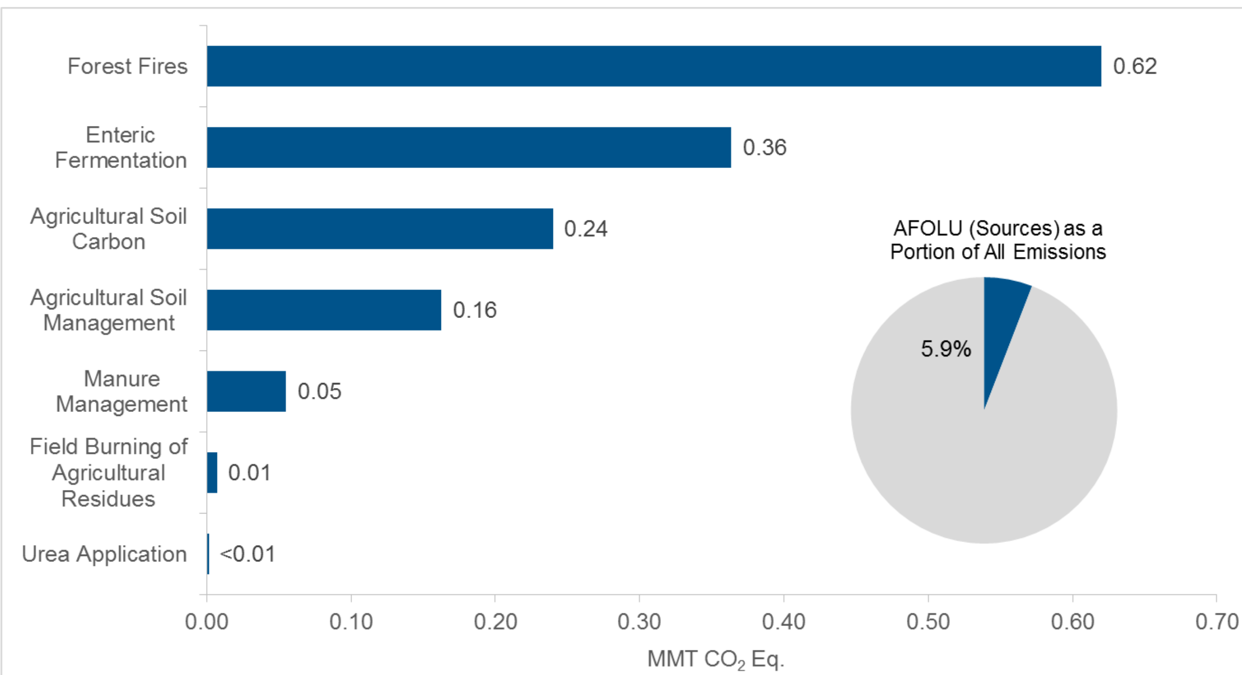


Table 16: GHG Emissions from the AFOLU Sector by Category (MMT CO_2 Eq.)

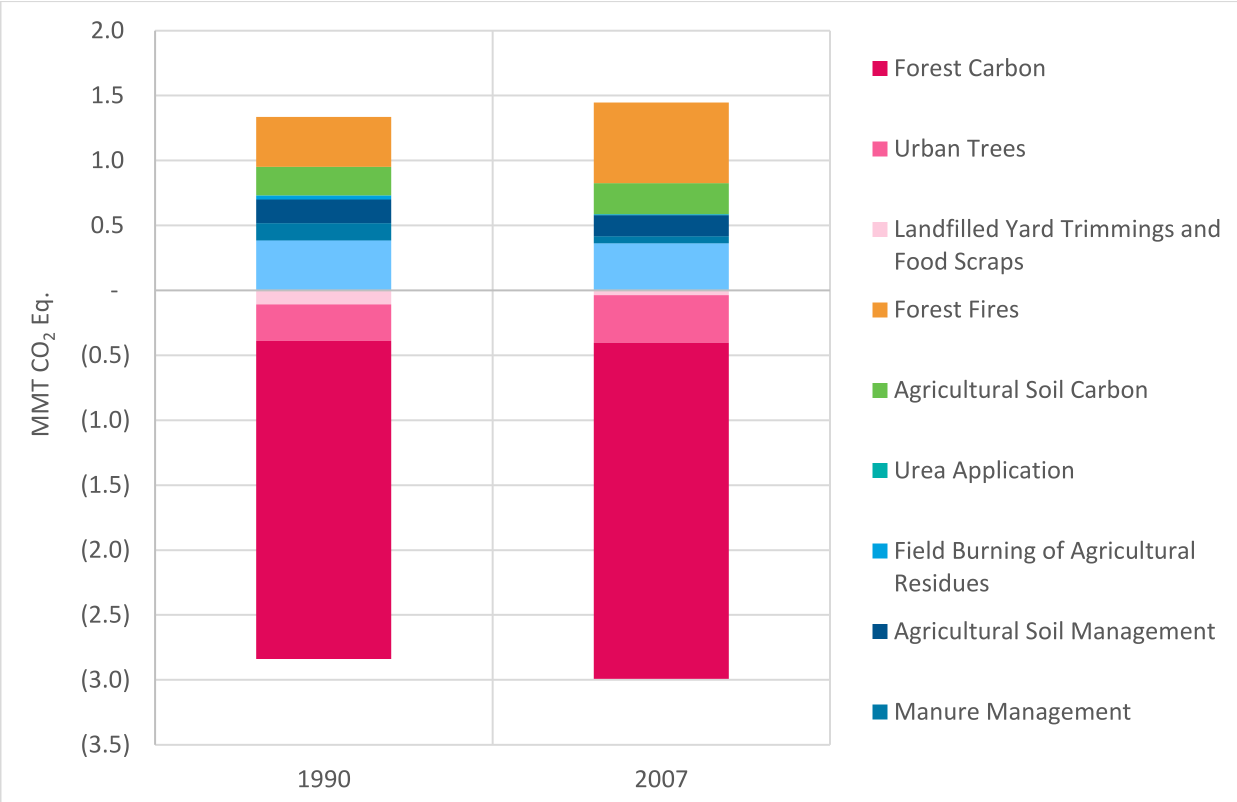
Category	1990	2007
Agriculture	**0.73**	**0.59**
Enteric Fermentation	0.38	0.36
Manure Management	0.13	0.05
Agricultural Soil Management	0.18	0.16
Field Burning of Agricultural Residues	0.03	0.01
Urea Application	+	+
Land Use, Land-Use Change, and Forestry	**(2.25)**	**(2.14)**
Agricultural Soil Carbon	0.22	0.24
Forest Fires	0.38	0.62
Landfilled Yard Trimmings and Food Scraps	(0.12)	(0.04)
Urban Trees	(0.28)	(0.37)
Forest Carbon	(2.45)	(2.59)
Total (Sources)	**1.34**	**1.45**
Total (Sinks)	**(2.85)**	**(3.00)**

+ Does not exceed 0.005 MMT CO_2 Eq.

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

Forest fires and enteric fermentation account for the largest share of AFOLU emissions in both 1990 and 2007, followed by agricultural soil management, agricultural soil carbon, manure management, field burning of agricultural residues, and urea application. Forest carbon accounts for the largest carbon sink, followed by urban trees and landfilled yard trimmings and food scraps. Figure 17 presents AFOLU emissions by source and sink in Hawaii for 1990 and 2007.

Figure 17: AFOLU Emissions by Source and Sink Category, 1990 and 2007 (MMT CO_2 Eq.)



4.1. Enteric Fermentation (IPCC Source Category 3A1)

Methane is produced as part of the digestive processes in animals, a microbial fermentation process referred to as enteric fermentation. The amount of CH_4 emitted by an animal depends upon the animal's digestive system, and the amount and type of feed it consumes (U.S. EPA 2017a). This source includes CH_4 emissions from dairy and beef cattle, sheep, goats, swine, and horses. Table 17 summarizes emissions from enteric fermentation in Hawaii for 1990 and 2007.

Table 17: CH_4 Emissions from Enteric Fermentation (MMT CO_2 Eq.)

Source	1990	2007
Enteric Fermentation	0.38	0.36

Methodology

The IPCC (2006) Tier 1 methodology was used to estimate emissions of CH_4 from enteric fermentation. Emissions were calculated using the following equation:

CH_4 emissions = Σ (for each animal type) animal population x animal-specific emission factor for CH_4 from cattle, sheep, goats, swine and horses (kg CH_4 per head per year)

Data Sources

Animal population data were obtained from the U.S. Department of Agriculture's (USDA) National Agriculture Statistics Service (NASS) (USDA 2017a, USDA 2017b). NASS reported annual population data for cattle and swine for 1990 and 2007. Population data for sheep, goats, and horses were obtained from the USDA Census of Agriculture, which is compiled every five years. The USDA's 2007 Census of Agriculture (USDA 2009) provided population data for sheep, goats, and horses for 2007. Population data for sheep, goats, and horses for 1990 were interpolated based on population data for 1987 and 1992 from the 1992 USDA Census of Agriculture (USDA 1994).

Yearly emission factors for the several cattle types available for the state of Hawaii for 1990 and 2007 were obtained from the EPA's State Inventory Tool (U.S. EPA 2017a).[17] Emission factors for bulls, sheep, goats, horses, and swine were obtained from the U.S. Inventory (U.S. EPA 2017a).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from enteric fermentation have increased by 44 percent and 46 percent, respectively. Calculations were updated to use GWP values from the *IPCC Fourth Assessment Report*, assuming a 100-year time horizon (IPCC 2007). Emission factors obtained from the EPA's State Inventory Tool (U.S. EPA 2017a) were higher for most cattle types. Animal population data for sheep, goats, and horses for 2007, which was estimated in the 2008 inventory report, increased based on the 2007 USDA Census of Agriculture (USDA 2009). Population data for cattle and swine remained unchanged. Emission factors for sheep, goats, horses, and swine remained unchanged, while the emission factor for bulls increased.

4.2. Manure Management (IPCC Source Category 3A2)

The main GHGs emitted by the treatment, storage, and transportation of livestock manure are CH_4 and N_2O. Methane is produced by the anaerobic decomposition of manure. Direct N_2O emissions are produced through the nitrification and denitrification of the organic nitrogen (N) in livestock dung and urine. Indirect N_2O emissions result from the volatilization of N in manure and the runoff and leaching of N from manure into water (U.S. EPA 2017a). This category includes CH_4 and N_2O emissions from dairy and beef cattle, sheep, goats, swine, horses, and chickens. Table 18 summarizes emissions from manure management in Hawaii for 1990 and 2007.

Table 18: Manure Management Emissions by Gas (MMT CO_2 Eq.)

Source	1990			2007		
	CH_4	N_2O	Total	CH_4	N_2O	Total
Manure Management	0.11	0.02	**0.13**	0.04	0.01	**0.05**

Note: Totals may not sum due to independent rounding.

[17] The State Inventory Tool includes yearly emission factors for the following cattle types: dairy cows, beef cows, dairy replacement heifers, other dairy heifers, beef replacement heifers, other beef heifers, steers, and weanlings.

Methodology

The IPCC (2006) Tier 2 method was employed to estimate emissions of both CH_4 and N_2O using the following equations:

CH_4 emissions = animal population × typical animal mass × volatile solids excretion per kilogram animal mass × maximum potential emissions × weighted methane conversion factor

N_2O emissions = [Σ (for each waste management system) typical animal mass × N excretion per kg animal mass per day × 365 × (1 - percent N volatilized) × % of manure managed in that system × emission factor for that system] × conversion from N_2O-N to N_2O, 44/28

Data Sources

Animal population data for cattle, swine, and chickens were obtained from the USDA NASS (USDA 2017a, USDA 2017b, USDA 2017c). Population data for sheep, goats, and horses were obtained from the USDA Census of Agriculture, with year 2007 data obtained directly from the 2007 USDA Census of Agriculture (USDA 2009) and year 1990 data interpolated from data available for 1987 and 1992 in the 1992 USDA Census of Agriculture (USDA 1994).

To develop CH_4 emissions from manure management, typical animal mass, maximum potential emissions by animal, Hawaii-specific values for volatile solids (VS) excretion rates and weighted methane conversion factors (MCFs) were all obtained from the EPA's State Inventory Tool (U.S. EPA 2017c).

To develop N_2O emissions from manure management, nitrogen (N) excretion rates by animal type were also obtained from the EPA's State Inventory Tool (U.S. EPA 2017c). The distributions of waste by animal in different waste management systems (WMS) were obtained from the U.S. Inventory (U.S. EPA 2017a). Weighted MCFs take into account the percent of manure for each animal type managed in different WMS. Emission factors for the different WMS were obtained from the *2006 IPCC Guidelines* (IPCC 2006).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from manure management have increased by 9 percent and 10 percent, respectively. Calculations were updated to use GWP values from the *IPCC Fourth Assessment Report*, assuming a 100-year time horizon (IPCC 2007). Volatile solids excretion rates were updated to reflect Hawaii-specific values rather than values for the U.S. "West" region. The typical animal mass for sheep and assumed distribution of manure among manure management system types for sheep, goats, swine, and horses were updated based on EPA's State Inventory Tool (U.S. EPA 2017c). Animal population data for sheep, goats, and horses for 2007, which were estimated in the 2008 inventory report based on 1992 and 1997 USDA Census of Agriculture data, increased based on the 2007 USDA Census of Agriculture (USDA 2009). Population data for cattle, swine, and chicken remained unchanged.

4.3. Agricultural Soil Management (IPCC Source Categories 3C4 and 3C5)

Nitrous oxide is produced naturally in soils through the nitrogen (N) cycle. Many agricultural activities, such as the application of N fertilizers, increase the availability of mineral N in soils that lead to direct N_2O emissions from nitrification and denitrification (U.S. EPA 2017a). This category includes N_2O emissions from synthetic fertilizer, organic fertilizer, manure N, as well as crop residue inputs from sugarcane, pineapples, sweet potatoes, ginger root, taro and corn for grain. Table 19 summarizes emissions from agricultural soil management in Hawaii for 1990 and 2007.

Table 19: N_2O Emissions from Agricultural Soil Management (MMT CO_2 Eq.)

Source	1990	2007
Agricultural Soil Management	0.18	0.16

Methodology

The IPCC (2006) Tier 1 approach was used to calculate N_2O emissions from agricultural soil management. The overall equation for calculating emissions is as follows:

$$N_2O \text{ emissions} = \text{direct } N_2O \text{ emissions} + \text{indirect } N_2O \text{ emissions}$$

The following equations were used to calculate direct emissions:

$$\text{Direct } N_2O \text{ emissions} = [(N_F \times EF_F) + (N_O \times EF_F) + (N_{CR} \times EF_F) + (N_{PRP1} \times EF_{PRP1}) + (N_{PRP2} \times EF_{PRP2})] \times 44/28$$

where,

- N_F = N inputs to agricultural soils from synthetic fertilizers
- N_O = N inputs to agricultural soils from organic fertilizers
- N_{CR} = N inputs to agricultural soils from crop residues
- N_{PRP1} = N inputs to agricultural soils from pasture, range, and paddock manure from cattle, swine, and poultry
- N_{PRP2} = N inputs to agricultural soils from pasture, range, and paddock manure from sheep, goats, and horses
- EF_F = emission factor for direct N_2O emissions from synthetic and organic fertilizers and crop residues (0.01 kg N_2O-N/kg N input)
- EF_{PRP1} = emission factor for direct N_2O emissions from pasture, range, and paddock manure from cattle, swine, and poultry (0.02 kg N_2O-N/kg N input)
- EF_{PRP2} = emission factor for direct N_2O emissions from pasture, range, and paddock manure from sheep, goats, and horses (0.01 kg N_2O-N/kg N input)
- 44/28 = conversion from N_2O-N to N_2O

$$\text{N inputs to agricultural soils from crop residues } (N_{CR}) = \text{above-ground residue dry matter} \times \text{crop area} \times [\text{N content of aboveground residues} + \text{ratio of belowground residues to harvested yield for crop} \times \text{N content of belowground residues}]$$

$$\text{Above-ground residue dry matter} = \text{Fresh weight yield (kg fresh weight harvested/ha)} \times \text{dry matter fraction of harvested crop} \times \text{slope} + \text{intercept}$$

The following equations were used to calculate indirect emissions:

$$\text{Indirect } N_2O \text{ emissions} = \text{indirect emissions from volatilization} + \text{indirect emissions from leaching/runoff}$$

$$\text{Indirect emissions from volatilization} = [(N_F \times L_{vol\text{-}F}) + (N_O \times L_{vol\text{-}O}) + (N_{PRP} \times L_{vol\text{-}O})] \times E_{Fvol} \times 44/28$$

$$\text{Indirect emissions from leaching/runoff} = (N_F + N_O + N_{CR} + N_{PRP}) \times L_{leach} \times EF_{leach} \times 44/28$$

where,

N_F	= N inputs to agricultural soils from synthetic fertilizers
N_O	= N inputs to agricultural soils from organic fertilizers
N_{CR}	= N inputs to agricultural soils from crop residues
N_{PRP}	= N inputs to agricultural soils from pasture, range, and paddock manure from all animals
$L_{vol\text{-}F}$	= fraction N lost through volatilization from synthetic fertilizer inputs (0.10)
$L_{vol\text{-}O}$	= fraction N lost through volatilization from organic fertilizer and manure inputs (0.20)
L_{leach}	= fraction N lost through leaching/runoff from all N inputs (0.30)
EF_{vol}	= emission factor for indirect N_2O emissions from N volatilization (0.010 kg N_2O-N / kg NH_3–N + NOχ–N volatilized)
EF_{leach}	= emission factor for N_2O emissions from pasture, range, and paddock manure from cattle, swine, and poultry (+75 kg N_2O-N / kg N leached/runoff)
44/28	= conversion from N_2O-N to N_2O

Data Sources

Annual sugarcane area and production estimates used to estimate emissions from crop residue N additions were obtained from NASS (USDA 2017d). For other crops (i.e., pineapples, sweet potatoes, ginger root, taro, and corn for grain), data for 2007 were obtained from the 2007 Census of Agriculture (USDA 2009) and data for 1990 were estimated based on interpolations between data for 1987 and 1992 from the 1992 USDA Census of Agriculture (USDA 1994). Percent distribution of waste to various animal waste management systems, used to estimate manure N additions to pasture, range, and paddock soils, were obtained from the U.S. Inventory (U.S. EPA 2017a).

Synthetic and organic fertilizer N application data were obtained from the annual publication of Association of American Plant Food Control Officials (AAPFCO 1995-2013, TVA 1991-1994). According to these data sources, commercial organic fertilizer is not applied in Hawaii.

Crop residue factors for corn were obtained from the *2006 IPCC Guidelines* (IPCC 2006). Crop residue factors for tubers were used for sweet potatoes, ginger root, and taro. No residue factors nor adequate proxy factors were available for pineapples or sugarcane, so crop residue N inputs from these crops were not included. However, as nearly 100 percent of aboveground sugarcane residues are burned in Hawaii, there is little crop residue N input from sugarcane. All emission and other factors are IPCC (2006) defaults.

Animal population data are used to calculate the N inputs to agricultural soils from pasture, range, and paddock manure from all animals. Animal population data for cattle, swine and chickens were obtained from the USDA NASS (USDA 2017a, USDA 2017b, USDA 2017c, USDA 2017d). Population data for sheep, goats, and horses were obtained from the USDA Census of Agriculture, with year 2007 data obtained directly from the 2007 USDA Census of Agriculture (USDA 2009) and year 1990 data interpolated from data available for 1987 and 1992 in the 1992 USDA Census of Agriculture (USDA 1994).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from agricultural soil management have decreased by 3 percent and 2 percent, respectively. Calculations were updated to use GWP values from the *IPCC Fourth Assessment Report*, assuming a 100-year time horizon (IPCC 2007). Crop production data for 2007 for pineapples, sweet potatoes, ginger root, taro and corn for grain were updated based on the 2007 Census of Agriculture (USDA 2009). In addition, the typical animal mass for sheep and assumed distribution of manure among manure management system types for sheep, goats, swine, and horses were updated. Also, animal population data, used to calculate N inputs to agricultural soils from manure from sheep, goats, and horses for 2007 increased based on the 2007 USDA Census of Agriculture (USDA 2009).

4.4. Field Burning of Agricultural Residues (IPCC Source Category 3C1b)

Field burning is a method that farmers use to manage the vast amounts of agricultural crop residues that can be created during crop production. Crop residue burning is a net source of CH_4 and N_2O, which are released during combustion (U.S. EPA 2017a). This source includes CH_4 and N_2O emissions from sugarcane burning, which is the only major crop in Hawaii whose residues are regularly burned (Hudson 2008). Table 20 summarizes emissions from field burning of agricultural residues in Hawaii for 1990 and 2007.

Table 20: Field Burning of Agricultural Residues Emissions by Gas (MMT CO_2 Eq.)

Source	1990			2007		
	CH_4	N_2O	Total	CH_4	N_2O	Total
Field Burning of Agricultural Residues	0.03	+	**0.03**	0.01	+	**0.01**

+ Does not exceed 0.005 MMT CO_2 Eq.

Note: Totals may not sum due to independent rounding.

Methodology

The IPCC/UNEP/OECD/IEA (1997) Tier 1 approach was used to calculate CH_4 and N_2O emissions from field burning of agricultural residues. Compared to the IPCC (2006) approach, the IPCC/UNEP/OECD/IEA (1997) method is considered more appropriate for conditions in the United States because it is more flexible for incorporating country-specific data (U.S. EPA 2017a). Emissions were calculated using the following equation:

CH_4 and N_2O Emissions = crop production × residue-crop ratio × dry matter fraction × fraction of crop residue burned × burning efficiency × combustion efficiency × C or N content of residue × emissions ratio × conversion factor

where,

Crop production	= annual weight of crop produced
Residue-crop ratio	= amount of residue produced per unit of crop production (0.19)
Fraction of crop residue burned	= amount of residue which is burned per unit of total residue (95%)
Dry matter fraction	= amount of dry matter per unit of biomass (62%)
C or N content of residue	= amount of C or N per unit of dry matter (42.4% and 0.4%, respectively)
Burning efficiency	= the proportion of prefire fuel biomass consumed (0.81)
Combustion efficiency	= the proportion of C or N released with respect to the total amount of C or N available in the burned material, respectively (0.68)
Emissions ratio	= g CH_4-C/g C released or g N_2O-N/g N release (+5 and +7, respectively)
Conversion factor	= conversion of CH_4-C to C or N_2O-N to N (16/12 and 44/28, respectively)

Data Sources

Annual sugarcane area and production estimates used to estimate emissions from crop residue N additions were obtained from USDA NASS (USDA 2017d). The residue/crop ratio and burning efficiency were taken from Kinoshita (1988). Dry matter fraction, fraction of carbon and N, and combustion efficiency were taken from Turn et al. (1997). Fraction of residue burned was taken from Ashman (2008).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from field burning of agricultural residues have increased by 15 percent for both inventory years. Calculations were updated to use GWP values from the *IPCC Fourth Assessment Report*, assuming a 100-year time horizon (IPCC 2007).

4.5. Urea Application (IPCC Source Category 3C3)

Urea ($CO(NH_2)_2$) is a nitrogen fertilizer that is often applied to agricultural soils. When urea is added to soils, bicarbonate forms and evolves into CO_2 and water (IPCC 2006). Table 21 summarizes emissions from urea application in Hawaii for 1990 and 2007.

Table 21: CO_2 Emissions from Urea Application (MMT CO_2 Eq.)

Source	1990	2007
Urea Application	+	+

+ Does not exceed 0.005 MMT CO_2 Eq.

Methodology

The IPCC (2006) Tier 1 methodology was used to estimate emissions from urea application. Emissions were calculated using the following equation:

$$CO_2 \text{ Emissions} = M \times EF \times CO_2\text{-}C$$

where:

M = annual amount of urea fertilization, tonnes
EF = emission factor, 0.2 tonnes C/ton urea
CO_2-C = conversion of carbon to CO_2, 44/12, dimensionless

Data Sources

Fertilizer sales data were obtained from the annual publication of Association of American Plant Food Control Officials (AAPFCO 1995-2013, TVA 1991-1994). AAPFCO reports fertilizer sales data for each fertilizer year (July through June).[18] Historical usage patterns were used to apportion these sales to the inventory calendar years (January through December).

[18] Fertilizer sales are reported by fertilizer year, corresponding to the growing season. The 2007 fertilizer year, for example, runs from July 2006 to June 2007.

The *2006 IPCC Guidelines* default emission factor of 0.2 tonnes C/ton of urea was used to estimate the carbon emissions, in the form of CO_2, that result from urea application.

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from urea application have not changed as no changes were made to the methodology, GWP values, emission factors, or activity data.

4.6. Agricultural Soil Carbon (IPCC Source Categories 3B2, 3B3)

Agricultural soil carbon refers to the change in carbon stock in agricultural soils—either in cropland or grasslands—that have been converted from other land uses. Agricultural soils can be categorized into organic soils, which contain more than 12 to 20 percent organic carbon by weight, and mineral soils, which typically contain 1 to 6 percent organic carbon by weight (U.S. EPA 2017a). Organic soils that are actively farmed tend to be sources of carbon emissions as soil carbon is lost to the atmosphere due to drainage and management activities. Mineral soils can be sources of carbon emissions after conversion, but fertilization, flooding, and management practices can result in the soil being either a net source or net sink of carbon. Nationwide, sequestration of carbon by agricultural soils is largely due to enrollment in the Conservation Reserve Program, conservation tillage practices, increased hay production, and intensified crop production. Table 22 summarizes emissions from agricultural soils in Hawaii for 1990 and 2007.

Table 22: CO_2 Emissions from Agricultural Soils (MMT CO_2 Eq.)

Source	1990	2007
Agricultural Soil Carbon	0.22	0.24

Methodology

Emission estimates for this source were taken directly from the U.S. Agriculture and Forestry Greenhouse Gas Inventory (USDA 2008) and the U.S. Inventory (U.S. EPA 2009).[19] These estimates were developed by Dr. Stephen Ogle of Colorado State University using the Century biogeochemical model, which simulates changes in soil carbon nationwide based on weather patterns, land use, management activities, and water dynamics.

[19] 2007 state-level emissions from the most recent version of the U.S. Inventory (U.S. EPA 2017a) were not available for incorporation into this report.

Data Sources

Estimates of emissions from Hawaii's agricultural soils were available for the year 1997 in the U.S. Agriculture and Forestry Greenhouse Gas Inventory (USDA 2008). 1997 values were used as a proxy for 1990. Values for 2007 were available from the 1990-2007 U.S. Inventory (U.S. EPA 2009).[20]

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 emission estimates from agricultural soil carbon have not changed, while 2007 emission estimates have decreased by 2 percent. For the 2008 inventory report, 2006 estimates from the 1990-2006 U.S. Inventory were used as a proxy for 2007 estimates. For this inventory report, the estimate was updated to reflect the 2007 estimate (U.S. EPA 2009).

4.7. Forest Fires (IPCC Source Category 3C1a)

Forest fires emit CO_2, CH_4, and N_2O as biomass is combusted. This source includes emissions from forest fires caused by lightning, campfire, smoking, debris burning, arson, equipment, railroads, children, and other miscellaneous activities reported by the Hawaii Department of Land and Natural Resources (DLNR). Table 23 summarizes emissions from forest fires in Hawaii for 1990 and 2007.

Table 23: Forest Fire Emissions by Gas (MMT CO_2 Eq.)

Source	1990				2007			
	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total
Forest Fires	0.34	0.03	0.02	**0.38**	0.55	0.04	0.03	**0.62**

Note: Totals may not sum due to independent rounding.

Methodology

The IPCC (2006) Tier 1 methodology was used to calculate GHG emissions from forest fires according to the following equation:

$$\text{Emissions} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

where,

- A = area burnt, hectares (ha)
- M_B = mass of fuel available for combustion, tonnes/ha
- C_f = combustion factor, dimensionless
- G_{ef} = emission factor, g/kg dry matter burnt
- 10^{-3} = conversion of kg to tonnes

[20] 2007 state-level emissions from the most recent version of the U.S. Inventory (U.S. EPA 2017a) were not available for incorporation into this report.

Data Sources

Data for years 1994 and 2007 on acres burned by wildfire were obtained from the DLNR *Annual Wildfire Summary Report*, published by the Fire Management Program of the DLNR (and also found in DBEDT's Hawaii Warehouse) (DLNR 1994-2008). Due to limited data availability, 1994 data were used as proxy data for 1990.

Because acres burned data is related to wildland, it was necessary to develop a forestland to wildland ratio to estimate area of forestland burned. "Wildland under Protection" data, in million acres, were obtained for years 1998 and 2002 from the National Association of State Foresters (1998, 2002). 1998 data were used for 1990 and 2002 data were used for 2007.

Managed forestland acreage time series data were obtained from the Hawaii Warehouse (DBEDT 2017b). Area estimates of private forestland in the conservation district were summed with reserve forestland in the conservation district, forested natural areas and wooded farmland in order to generate total managed forested land area in Hawaii for 1990 and 2007. The annual carbon density for the lower 48 states (i.e., the fuel available for combustion) was provided by the U.S. Forest Service (USFS 2014).[21]

IPCC (2006) default combustion factors for tropical forest and shrubland were weighted using the ratio of Hawaii forest to shrubland area provided in the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program (NOAA-CCAP) Descriptive Summary of the Changes in the Main Eight Hawaiian Islands (2000). According to NOAA-CCAP, roughly half of Hawaii's forestland is shrub/scrubland, defined as land with vegetation less than 20 feet tall. Emission factors for CH_4 and N_2O emissions were obtained from IPCC (2006).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from forest fires have increased by 140 percent and 408 percent, respectively. Calculations were updated to use GWP values from the *IPCC Fourth Assessment Report*, assuming a 100-year time horizon (IPCC 2007). The methodology for estimating emissions from forest fires was revised to be consistent with IPCC (2006) guidelines, as opposed to IPCC (2003) guidelines. Combustion and emissions factors were also updated using the *2006 IPCC Guidelines* (IPCC 2006).

The amount of wildland under protection in 2002 was revised to the correct units for this calculation (hectares), resulting in a higher ratio of forest to wildland and thus higher emissions relative to the 2008 inventory report. The amount of fuel available for combustion was updated to the annual carbon density for the lower 48 states as provided by the USFS (2014). Previously, an average carbon density for all years was assumed in the 2008 inventory report.

In addition, for the 2008 inventory report, forest acres burned data were not available for the year 2007 and were proxied using 2006 data. The estimates presented in this inventory report were updated using

---

[21] Extensive research was conducted to find a Hawaii-specific factor for carbon density. Due to a lack of such a factor, annual carbon density for the lower 48 states was used, as provided by the USFS (2014).

forest acres burned data for year 2007, as reported by the DLNR. Actual forest acres burned data for year 2007 were more than twice the amount assumed for the 2008 inventory report.

4.8. Landfilled Yard Trimmings and Food Scraps (IPCC Source Category 3B5a)

Yard trimmings (i.e., grass clippings, leaves, and branches) and food scraps continue to store carbon for long periods of time after they have been discarded in landfills. Table 24 summarizes changes in carbon stocks in landfilled yard trimmings and food scraps in Hawaii for 1990 and 2007.

Table 24: CO_2 Flux from Landfilled Yard Trimmings and Food Scraps (MMT CO_2 Eq.)

Sink	1990	2007
Landfilled Yard Trimmings and Food Scraps	(0.12)	(0.04)

Note: Parentheses indicate negative values or sequestration.

Methodology

Estimates of the carbon sequestration in landfilled yard trimmings and food scraps for Hawaii were generated by the EPA's State Inventory Tool (U.S. EPA 2017d). The State Inventory Tool calculates carbon stock change from landfilled yard trimmings and food scraps based on IPCC (2003) and IPCC (2006) Tier 2 methodologies using the following equation:

$$LFC_{i,t} = \Sigma\, W_{i,n} \times (1 - MC_i) \times ICC_i \times \{[CS_i \times ICC_i] + [(1 - (CS_i \times ICC_i)) \times e^{-k \times (t-n)}]\}$$

where:

t	= the year for which carbon stocks are being estimated
$LFC_{i,t}$	= the stock of carbon in landfills in year t, for waste i (grass, leaves, branches, and food scraps)
$W_{i,n}$	= the mass of waste i disposed in landfills in year n, in units of wet weight
n	= the year in which the waste was disposed, where 1960 < n < t
MC_i	= moisture content of waste i
CS_i	= the proportion of initial carbon that is stored for waste i
ICC_i	= the initial carbon content of waste i
e	= the natural logarithm
k	= the first order rate constant for waste i, and is equal to 0.693 divided by the half-life for decomposition

The State Inventory Tool uses data on the generation of food scraps and yard trimmings for the entire United States. Additionally, it uses data on the amounts of organic waste composted, incinerated, and landfilled each year to develop an estimate of the yard trimmings and food scraps added to landfills each year nationwide. State and national population data is then used to scale landfilled yard trimmings and food scraps down to the state level. These annual additions of carbon to landfills and an estimated decomposition rate for each year are then used, along with carbon conversion factors, to calculate the carbon pool in landfills for each year.

Data Sources

Default values from the State Inventory Tool (U.S. EPA 2017d) for the composition of yard trimmings (i.e., amount of grass, leaves, and branches that are landfilled), food scraps, and their carbon content were used to calculate carbon inputs into landfills. Waste generation data for each year, also obtained from the State Inventory Tool (U.S. EPA 2017d), were used to calculate the national-level estimates in 1990 and 2007. Hawaii population data were obtained from the State of Hawaii Data Warehouse (DBEDT 2017b).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 carbon stock change estimates from landfilled yard trimmings and food scraps have increased by 12 percent and 21 percent, respectively. The current version of the State Inventory Tool contains updated factors for the proportion of carbon stored in grass, leaves, branches, and food scraps, and the decay rate of these materials. In addition, the ratio of Hawaii population to national population for 1990 and 2007 increased, leading to greater amounts of landfilled yard trimmings and food scraps scaled down to Hawaii from the national level, and therefore, increased carbon stock estimates.

4.9. Urban Trees (IPCC Source Category 3B5a)

Trees in urban areas (i.e., urban forests) sequester carbon from the atmosphere. Urban areas in Hawaii represented approximately 5 percent of Hawaii's total area in 1990 and 6 percent of Hawaii's total area in 2010 (U.S. Census Bureau 1990 and 2012; DBEDT 2017b). Table 25 summarizes carbon flux from urban trees in Hawaii for 1990 and 2007.

Table 25: CO_2 Flux from Urban Trees (MMT CO_2 Eq.)

Sink	1990	2007
Urban Trees	(0.28)	(0.37)

Note: Parentheses indicate negative values or sequestration.

Methodology

Carbon flux from urban trees was calculated using a methodology consistent with the U.S. Inventory (U.S. EPA 2017a) and the IPCC (2006) default Gain-Loss methodology. Carbon flux estimates from urban trees were calculated using the following equation.

$$CO_2\ Flux = A \times T_{percent} \times S_c \times CO_2\text{-}C$$

where:

A	= total urban area (including clusters), km^2
$T_{percent}$	= percent of urban area covered by trees, dimensionless
S_c	= C sequestration rates of urban trees, tonnes C/km^2
CO_2-C	= conversion of carbon to CO_2, 44/12, dimensionless

Data Sources

The City and County of Honolulu's *Municipal Forest Resource Analysis* (Vargas et al. 2007) provided data on Honolulu's carbon sequestration rates for urban trees. Using this Honolulu-specific data, a rate of annual carbon sequestration per square meter of tree canopy (kg C/m^2 tree cover) was calculated for Hawaii.

Census-defined urbanized area and cluster values were used to calculate urbanized area in Hawaii. [22] State-level urban area estimates were adapted from the U.S. Census (1990) to be consistent with the definition of urban area and clusters provided in the 2000 U.S. Census (Nowak et al. 2005). Urban area and cluster data for 2000 and 2010 were provided directly from the U.S. Census (2002, 2012). A linear trend was fitted to the 2000 and 2010 data to establish a time series from 2000 to 2007.

Nowak and Greenfield (2012) developed a study to determine percent tree cover by state. According to Nowak (2012), 39.9 percent of urban areas in Hawaii are covered by trees. With an estimate of total urban tree cover for Hawaii, the Hawaii-specific sequestration factor (kg C/m^2 tree cover) was applied to this area to calculate total C sequestration by urban trees (MT C/year).

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 carbon sequestration from urban trees has increased (i.e., resulted in more sinks) by 148 percent and 185 percent, respectively. The significant increases in estimates of urban area and tree cover resulted in increased sequestration from urban trees in Hawaii for 1990 and 2007 relative to the 2008 inventory report.

For the 2008 inventory report, a state-specific estimate of Hawaii's urban tree cover was not available. The national average urban tree cover (27.1 percent) was previously used to estimate how much of Hawaii's urbanized area is covered by tree canopy. Since the 2008 inventory report, Nowak and Greenfield (2012) published *Tree and impervious cover in the United States*, which determined that 39.9

[22] Definitions for urbanized area changed between 1990, 2000, and 2010. According to the U.S. Inventory, "the 1990 U.S. Census defined urban land as 'urbanized areas,' which included land with a population density greater than 1,000 people per square mile, and adjacent 'urban places,' which had predefined political boundaries and a population total greater than 2,500. In 2000, the U.S. Census replaced the 'urban places' category with a new category of urban land called an 'urban cluster,' which included areas with more than 500 people per square mile. In 2010, the Census updated its definitions to have 'urban areas' encompassing Census tract delineated cities with 50,000 or more people, and 'urban clusters' containing Census tract delineated locations with between 2,500 and 50,000 people" (U.S. EPA 2017a).

percent of urban area in Hawaii is covered by trees. The current methodology applies this Hawaii-specific percentage to Hawaii's urban area.

To ensure time-series consistency between urban area estimates from U.S. Census reports, urban clusters were incorporated into the 1990 and 2000 urban area activity data, increasing the urban area estimates used in the previous inventory report. Urban clusters are defined in the 2000 U.S. Census as "surrounding census blocks that have an overall density of at least 500 people per square mile." The 1990 U.S. Census did not include urban clusters as a classification but instead defined "urban places" as an additional category for urban area based on population and political boundaries (U.S. EPA 2009). Urban area estimates for 1990 in Nowak et al. (2005) were used in this report because they are consistent with the definition of urban area and clusters provided in the 2000 U.S. Census. 2010 U.S. Census data were also incorporated to develop estimates of urban area for 2007.

4.10. Forest Carbon (IPCC Source Category 3B1a)

Hawaii forests and shrubland contain carbon stored in various carbon pools, which are defined as reservoirs with the capacity to accumulate or release carbon (IPCC 2006). This category includes estimates of carbon sequestered in forests and shrubland aboveground biomass, which is defined as living vegetation above the soil, and belowground biomass, which is defined as all biomass below the roots (IPCC 2006). Table 26 summarizes carbon flux from forests and shrubland in Hawaii for 1990 and 2007.

Table 26: C Flux from Forests (MMT CO_2 Eq.)

Sink	1990	2007
Forest Carbon	(2.45)	(2.59)

Note: Parentheses indicate negative values or sequestration.

Methodology

The Tier 1 Gain Loss Method as outlined by the *2006 IPCC Guidelines* (IPCC 2006) was used to calculate carbon flux in managed Hawaii forests.[23] This method requires forestland acreage time series data as well as aboveground biomass growth rate, the ratio of below ground biomass to aboveground biomass, and the carbon fraction. The Gain Loss method calculates annual increase in biomass carbon stocks using the following equation:

$$\text{Forest } CO_2 \text{ Flux} = (\Sigma_i(A_i \times G_{TOTAL\_i} \times CF_i)) \times CO_2\text{-C}$$

[23] Managed forests, under IPCC (2006) guidelines, are deemed to be a human-influenced GHG sink and, accordingly, are included here. This encompasses any forest that is under any sort of human intervention, alteration, maintenance, or legal protection. Unmanaged forests are not under human influence and thus out of the purview of this inventory.

where,

A	= forest land area, hectares
$G_{TOTAL\_i,j}$	= mean annual biomass growth, tonnes of dry matter/hectare
$CF_{i,j}$	= carbon fraction of dry matter, tonnes C/tonne of dry matter
CO_2-C	= conversion of carbon to CO_2, 44/12, dimensionless
i	= forest type (forest or shrubland in Hawaii)

Data Sources

Managed forestland acreage time series data were obtained from the Hawaii Data Warehouse (DBEDT 2017b). Area estimates of private forestland in the conservation district were summed with reserve forestland in the conservation district, forested natural areas and wooded farmland in order to generate total managed forested land area in Hawaii for 1990 and 2007.

Roughly half of Hawaii's forestland is shrub/scrubland, defined as land with vegetation less than 20 feet tall (NOAA-CCAP 2000). Forestland was divided into two sub-categories: forest and shrub/scrubland using the island-specific forestland:shrubland ratios derived from the NOAA-CCAP study.

Mean biomass growth is derived by multiplying the average annual above-ground biomass growth by the sum of one and the ratio of below ground biomass to above ground biomass. This biomass growth was then multiplied by a carbon factor to determine the net addition of carbon. In obtaining the mean annual biomass growth and carbon fraction factors, the tropical Asia Insular IPCC (2006) default values were used as default factors for forest and shrubland.[24]

Changes in Estimates since the 2008 Inventory Report

Relative to the 2008 inventory report, 1990 and 2007 emission estimates from forest carbon have not changed as no changes were made to the methodology, GWP values, emission factors, or activity data.

[24] Extensive research was conducted to find Hawaii-specific carbon factors, during the course of which many Hawaii forest experts were contacted (Cole, Giardina, Litton, Bennet, Friday, and Ostertag 2008). However, the results of this research indicated that the IPCC defaults for tropical Asia insular land would be best suited for the revised estimates.

6. References

ICF. September 18, 2008; October 8, 2008.

AFOLU

AAPFCO (1995 through 2000, 2002 through 2013) Commercial Fertilizers. Association of American Plant Food Control Officials. University of Kentucky. Lexington, KY.

AAPFCO (2000) 1999-2000 Commercial Fertilizers Data, ASCII files. Available from David Terry, Secretary, AAPFCO.

Ashman (2008) Email communication. Janet Ashman, Hawaii Agriculture Research Center and Victoria Thompson, ICF International. September 25, 2008. Ms. Ashman cited an August 2004 report prepared for the U.S. Department of Energy by the Hawaiian Commercial & Sugar Co., Closed-Loop Biomass Co-Firing--Pilot-Scale and Full-Scale Test Results.

Bennet, K. (2008) Personal communication with Emily Rowan, ICF International, by email on September 24, 2008.

Cole, T. G. (2008) Personal communication with ICF International by email on September 25, 2008.

DBEDT (2017b) Department of Business, Economic, Development, and Tourism, State of Hawaii. Data Warehouse. Available online at http://dbedt.hawaii.gov/economic/datawarehouse/.

Department of Land and Natural Resources (DLNR) (1994 through 2008) Annual Wildfire Summary Report, Fire Management Program. Available at: http://www.state.hi.us/dlnr/dofaw/fmp/firedata.htm. Accessed July 2017.

Friday, J.B. (2008) Personal communication with Emily Rowan, ICF International, by email on September 23, 2008.

Giardina, C.P. (2008) Personal communication with Emily Rowan, ICF International, by email on September 24, 2008.

Hudson (2008) Personal communication. Mark Hudson, Director of the Hawaii Field Office of the USDA National Agricultural Statistics Service and Victoria Thompson, ICF International. August 22, 2008.

IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press. Cambridge, United Kingdom 996 pp.

IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The National Greenhouse Gas Inventories Programme, H.S. Eggleston, L. Buenida, K. Miwa, T. Ngara, and K. Tanabe, eds.; Institute for Global Environmental Strategies (IGES). Hayama, Kanagawa, Japan.

IPCC (2003) Good Practice Guidance for Land Use, Land-Use Change, and Forestry. The Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme, J. Penman, et al., eds. August 13, 2004. Available at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html.

IPCC/UNEP/OECD/IEA (1997) Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, United Nations Environment Programme, Organization for Economic Co-Operation and Development, International Energy Agency. Paris, France.

Kinoshita, C.M. (1988) Composition and processing of burned and unburned cane in Hawaii. International Sugar Journal. 90:1070, 34-37.

Litton, C. (2008) Personal communication with ICF by email on September 24, 2008.

National Association of State Foresters (2002) 2002 State Forestry Statistics; Resource Base. Available online at http://www.stateforesters.org/files/2002_20Stat_20Resource_20Base.pdf. 2002.

National Association of State Foresters (1998) 1998 Resource Base. Available at: http://www.stateforesters.org/files/1998ResourceBase.pdf. 1998.

NOAA-CCAP. Coastal Change Analysis Program, National Oceanic and Atmospheric Administration. (2000) Descriptive Summary of the Changes in the Main Eight Hawaiian Islands, Circa 2000. Descriptive summary and GIS data available at: http://www.csc.noaa.gov/crs/lca/hawaii.html.

Nowak, D.J., and Greenfield, E.J. (2012) "Tree and impervious cover in the United States" Landscape and Urban Planning Volume 107. Available at: https://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_nowak_002.pdf.

Nowak, D.J., Walton, J.T., Kaya, L.G., and Dwyer, J.F. (2005) "The Increasing Influence of Urban Environments on U.S. Forest Management." Journal of Forestry. Available online at: www.fs.fed.us/ne/newtown_square/publications/other_publishers/OCR/ne_2005_nowak002.pdf.

Turn, S.Q., B.M. Jenkins, J.C. Chow, L.C. Pritchett, D. Campbell, T. Cahill, and S.A. Whalen (1997) “Elemental characterization of particulate matter emitted from biomass burning: Wind tunnel derived source profiles for herbaceous and wood fuels.” Journal of Geophysical Research 102(D3):3683-3699.

TVA (1991 through 1994) Commercial Fertilizers. Tennessee Valley Authority, Muscle Shoals, AL.

U.S. Census Bureau. (2012) Census 2010 Urbanized Area and Urban Cluster Information. Available at: https://www2.census.gov/geo/docs/reference/ua/ua_st_list_all.txt.

U.S. Census Bureau. (2002) Census 2000 Urbanized Area and Urban Cluster Information. Available at: https://www.census.gov/geo/reference/ua/urban-rural-2000.html and http://www.census.gov/geo/www/ua/ua_2k.html.

U.S. Census Bureau. (1990) Census 1990 Urbanized Area and Urban Cluster Information.

USDA (2017a) Cattle and Calves, Hawaii. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, DC. Available online at: http://www.nass.usda.gov/QuickStats.

USDA (2017b) Hogs and Pigs, Hawaii. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, DC. Available online at: http://www.nass.usda.gov/QuickStats.

USDA (2017c) Chicken Inventory, Hawaii. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, DC. Available online at: http://www.nass.usda.gov/QuickStats.

USDA (2017d) Sugarcane for Sugar, Hawaii. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, DC. Available online at: http://www.nass.usda.gov/QuickStats.

USDA (2009) 2007 Census of Agriculture, Hawaii. U.S. Department of Agriculture, Washington, DC. Available online at: www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf.

USDA (2008) U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005. Technical Bulletin No. 1921. August 2008.

USDA (1994) 1992 Census of Agriculture, Hawaii. U.S. Department of Agriculture, Washington, DC. Available online at: http://agcensus.mannlib.cornell.edu/AgCensus/getVolumeOnePart.do?year=1992&part_id=847&number=11&title=Hawaii.

U.S. Environmental Protection Agency (U.S. EPA) (2017a) U.S. Inventory of GHG Emissions and Sinks, U.S. Environmental Protection Agency. April 2017.

U.S. Environmental Protection Agency (U.S. EPA) (2017c) State Inventory Tool, Agriculture Module. U.S. Environmental Protection Agency, January 2017.

U.S. Environmental Protection Agency (U.S. EPA) (2017d) State Inventory Tool, Land Use, Land-Use Change, and Forestry Module. U.S. Environmental Protection Agency, January 2017.

U.S. EPA (2009) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. U.S. Environmental Protection Agency. April 2009.

USFS (2014) Email communication between Mark Flugge, ICF, and Jim Smith, U.S. Forest Service.

Vargas, Kelaine et al. (2007) "City of Honolulu, HI Municipal Forest Resource Analysis." USDA Forest Service, Pacific SW Research Station. Nov 2007.

Appendix B: Sources Excluded from the Analysis

Table 32: Source Categories Excluded from the Analysis

Source Name	IPCC Source Category	Reason for Exclusion
Energy		
Fugitive Emissions from Solid Fuels	1B1	NO: Solid fuels (coal) are not produced or processed in Hawaii.
CO_2 Transport and storage	1C	NO: CO_2 is not transported or stored in Hawaii.
IPPU		
Lime Production	2A2	NO: Activity is not applicable to Hawaii.
Glass Production	2A3	NO: Activity is not applicable to Hawaii.
Other Process Uses of Carbonates	2A4	NO: Activity is not applicable to Hawaii.
Chemical Industry	2B	NO: Activity is not applicable to Hawaii.
Metal Industry	2C	NO: Activity is not applicable to Hawaii.
Non-Energy Products from Fuels and Solvent Use	2D	NO: Activity is not applicable to Hawaii.
Electronics Industry	2E	NO: Activity is not applicable to Hawaii.
SF_6 and PFCs from Other Product Uses	2G2	NO: Activity is not applicable to Hawaii.
N_2O from Product Uses	2G3	NO: Activity is not applicable to Hawaii.
AFOLU		
Land Converted to Forest Land	3B1b	NE: Data on land conversion and the period involved are not readily available.
Biomass Burning in Grassland	3C1c	NE: Data is not readily available and emissions from this source are likely very small.
Biomass Burning in All Other Land	3C1d	NO: Activity is not applicable to Hawaii.
Wetlands	3B4	NE: Data is not readily available and emissions from this source are likely very small.
Other Land	3B6	NE: Other Land is assumed to be unmanaged in Hawaii, so activity data are not readily available.
Liming	3C2	NE: Activity data are either withheld or zero.
Harvested Wood Products	3D1	NE: Data is not readily available and sinks from this source are likely very small.
Waste		
Incineration of Waste	5C1	In Hawaii, incineration of MSW occurs at waste-to-energy facilities and thus emissions are accounted for under the Energy sector.

NO (emissions are Not Occurring); NE (emissions are Not Estimated).