New Jersey GHG Inventory Standard Operating Procedure for the Land Use, Land Use Change, and Forestry Sector

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Acronyms

AGB	Aboveground biomass
AD	Activity data
AFOLU	Agriculture, forestry and other land use
AS	Archiving system
BGB	Belowground biomass
C	Carbon
CCAP	Coastal Change Analysis Program
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DOM	Dead organic matter
DW	Deadwood
EF	Emission factor
FAO	Food and Agriculture Organization of the United Nations
FIA	Forest inventory and analysis
FS	Forest Service (USDA agency)
Gg	Gigagrams
GHG	Greenhouse gas
GWP	Global warming potential
ha	Hectare
HWP	Harvested wood products
IA	Institutional arrangements
IIP	Inventory improvement plan
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
LI	Litter
LiDAR	Light Detection and Ranging
LULUCF	Land use, land-use change, and forestry
MMT	Million metric tons
N	Nitrogen
NAIP	National Agriculture Imagery Program
NASA CMS	National Aeronautics and Space Administration Carbon Monitoring System
NGHGI	U.S. national GHG inventory
NJ	New Jersey

NJDEP	New Jersey Department of Environmental Protection
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
N_2O	Nitrous oxide
NRCS	Natural Resources Conservation Service (USDA agency)
NRI	National Resources Inventory
NWL	Natural and working lands
PSU	Practical salinity unit
QA	Quality assurance
QC	Quality control
SCF	Stock change factor
SIT	State inventory tool
SOC	Soil organic carbon
SOP	Standard operating procedure
tC	Tonnes of carbon
tCO_2e	Tonnes of carbon dioxide equivalent
TNC	The Nature Conservancy
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USFS	United States Forest Service
VRV	Vegetated wetland remaining vegetated
WRW	Wetland remaining wetland
yr	Year

Glossary

Activity data	Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on land areas, management systems, and fertilizer use are examples of activity data.
Carbon flux	Carbon flux is the movement of carbon between land, oceans, atmosphere, and living things. Carbon flux is a measure of carbon exchanged between carbon stocks over a specified time.
Carbon pool/stock	Carbon pool is a system that has the capacity to accumulate or release carbon. The carbon pools involved in carbon stock changes include soil organic matter, biomass, and dead organic matter. The absolute quantity of carbon held within at a specified time is called carbon stock.
Carbon sink	A reservoir (natural or human, in soil, ocean, and plants) where a greenhouse gas, an aerosol or a precursor of a greenhouse gas is stored.
Category	Groupings of sources and sinks within each sector used for constructing the inventory. Key category are those that have a significant influence on inventory in terms of absolute level of emissions or removals.
CO_2 equivalent (CO_2e)	Carbon dioxide equivalent is the universal unit of measurement to indicate the global warming potential (GWP) of each greenhouse gas, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate different greenhouse gases against a common basis.
Default emission parameters	Average emission parameters provided by IPCC to estimate emissions and removals when location specific data is not available, used in Tier 1 calculations
Emission	The release of greenhouse gases into the atmosphere.
Emission factor	A factor that converts activity data into GHG emissions data.
Expert judgement	A carefully considered, well-documented qualitative or quantitative judgement made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field (IPCC 2006). Users can apply their own expert judgement or can consult experts.
GHG impacts	Changes in GHG emissions by GHG sources and carbon pools that result from a policy.
Global Warming Potential (GWP)	Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilograms of greenhouse gas emitted to the atmosphere to that from one kilogram of CO_2 over a period of time (e.g., 100 years).
Removal	Removal of GHG emissions from the atmosphere through sequestration or absorption, such as when CO2 is absorbed by biogenic materials during photosynthesis.
Sector	Groupings of related processes, sources, and sinks for reporting greenhouse gas emissions and removals, including Energy, Industrial processes and product use, Agriculture, Waste, and Land use, land use change and Forestry
Source	Any process, activity, or mechanism that releases a greenhouse gas into the atmosphere.
Stakeholders	People, organizations, communities, or individuals who are affected by and/or who have influence or power over the policy.
Surrogate data	Surrogate data refers to time series data that is produced using models to reproduce various statistical properties of a measured data set. The resulting surrogate data can then be used to supplement available data from which a mathematical model is built. Surrogate data may be generated (i.e., synthetic data) or transformed from another source.
Tier	Tier represents a level of methodological complexity, 1 is the basic method, 2 is intermediate, and 3 is the most demanding in terms of complexity and data requirements.
Uncertainty	1. Quantitative definition: Measurement that characterizes the dispersion of values that could reasonably be attributed to a parameter. 2. Qualitative definition: A general term that refers to the lack of certainty in data and methodological choices, such as the application of non-representative factors or methods, incomplete data, or lack of transparency.

Executive Summary

This **Standard Operating Procedure (SOP)** provides a comprehensive and standardized framework for estimating and reporting GHG emissions and removals from the **Land Use, Land-Use Change, and Forestry (LULUCF)** sector. Developed by the **New Jersey Department of Environmental Protection (NJDEP)** in partnership with the **Greenhouse Gas Management Institute (GHGMI)**, the SOP aligns with the methodologies outlined in the **2006 IPCC Guidelines for National Greenhouse Gas Inventories** and the practices used in the **U.S. national GHG inventory**.

The SOP aims to ensure that New Jersey's land-based GHG estimates are **transparent, consistent, comparable, complete, and accurate**, in accordance with international good practice. It provides detailed procedures for quantifying carbon stock changes and non-CO_2 emissions across the five IPCC land-use categories—**forest land, cropland, grassland, wetlands, settlements**—and for tracking land-use conversions between these categories over time.

Key methodological elements include guidance on:

- **Activity data and emission factor selection**, including the use of state-specific, national, or IPCC default parameters;
- **Calculation methods** for estimating carbon stock changes in living biomass, dead organic matter, and soil carbon pools;
- **Non-CO_2 emissions** from sources such as biomass burning, drained organic soils, wetland methane;
- **Use of geospatial datasets and land-use change matrices** to support annual area estimates and transitions among land categories; and
- **Integration with the Land GHG Inventory Calculator**, a spreadsheet-based tool that operationalizes the SOP's methods and facilitates consistent data entry, calculation, and documentation.

The SOP also defines the foundation for **data management and quality assurance/quality control (QA/QC)** procedures to maintain transparency and reproducibility. These include standardized naming conventions, metadata documentation, version control, and archiving requirements. This material enables the inventory team to implement QA/QC procedures for internal data checks, peer review, and correction of identified errors, ensuring the integrity of both source data and calculated results.

Recognizing the importance of institutional learning and continuous improvement, the SOP outlines improvement recommendation for subsequent inventory cycles undertaken by the state. This SOP is a living document and is expected to be regularly updated by the inventory team. There are also numerous tables to be used as templates to organize the information consistently, many are partially filled out awaiting input from the inventory team.

By establishing a clear and replicable methodology, this SOP provides the foundation for integrating robust land-based GHG estimates into New Jersey's overall greenhouse gas inventory. It strengthens the state's ability to assess progress toward its **80x50 emissions reduction target** and supports evidence-based decision-making in land management and climate policy. Ultimately, the SOP represents a key step in enhancing the **scientific credibility, transparency, and policy relevance** of New Jersey's climate reporting and mitigation planning efforts.

Introduction

Purpose

This document serves the following purposes:

- Documentation of GHG inventory methodologies for the New Jersey land sector
- Explanation of the inventory process
- Prioritization of improvements for future inventory cycles

As a "living document" this manual should be amended to incorporate forthcoming decisions about the inventory compilation process that the New Jersey State GHG inventory team may make.

The methodological approach and terminology utilized in this document is aligned with the UN Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC) GHG inventory guidelines for emissions and removals for the Land Use, Land Use Change and Forestry (LULUCF) category, which is synonymous with the NWL in state context.

This NWL sector GHG inventory manual is envisioned to be a component of the state-wide New Jersey GHG inventory documentation. GHG Inventory is compiled annually to track progress toward the 2030 and 2050 emission reduction goals[1] and reported by the New Jersey Department of Environmental Protection (NJDEP) biennially as a full report and mid-cycle update on years between.[2]

Additionally, Excel-based land-specific calculators are tools that accompany the calculation methodologies chosen by New Jersey to estimate the State's NWL inventory. The New Jersey-specific calculators serve as a key element of the GHG inventory process, as it contains a suite of calculation functionalities for emissions calculation for all **land** types in the State. The calculators contain the following features: modules for user-defined data, for activity data and emission factors, and calculation parameters, QA/QC functionality, summary of emissions and sinks estimates at different aggregation levels, and documentation of metadata. The calculators contain detailed instructions for users, which are aligned with the SOP steps for consistent implementation and performance of each calculation methodology.

Categories

The NWL sector system framework described in this document uses the IPCC land use categories, which are aligned with the National GHG Inventory (NGHGI). Under the IPCC, land is categorized by use into Forest Land, Cropland, Grassland, Wetlands, Settlements,

[1] 50% reduction from 2006 baseline by 2030, and 80% reduction from 2006 baseline by 2050

[2] New Jersey's Global Warming Response Act (GWRA) (P.L. 2007 c.112; P.L. 2019 c.197) and Governor Phil Murphy's Executive Order 274.

and Other Land. The land use definitions as well as methodology for each category are provided in the Methods and Data section. The NWL GHG inventory includes emissions and removals due to carbon stock changes as well as non-CO_2 emissions. All the NWL emission categories and those to included in the New Jersey NWL GHG inventory are outlined in Table 1.

Table 1. New Jersey NWL GHG emission categories

Category/subcategory name	Gas(es)	Included in the inventory[a]
Forest Land Remaining Forest Land		
Changes in forest carbon stocks	CO_2	Yes
Managed soils emissions	N_2O	No – not occurring
Emissions from drained organic soils (combined with Land Converted to Forest Land)	CO_2, CH_4, N_2O	No – not estimated
Land Converted to Forest Land		
Changes in forest carbon stocks	CO_2	Yes
Cropland Remaining Cropland[b]		
Changes in mineral and organic soil carbon stocks	CO_2	Yes
Changes in biomass carbon stocks (perennial crops)	CO_2	Yes
Emissions from drained organic soils (combined with Land Converted to Cropland)	CO_2, CH_4, N_2O	Yes
Land Converted to Cropland		
Changes in all carbon stocks	CO_2	Yes
Grassland Remaining Grassland		
Changes in mineral and organic soil carbon stocks	CO_2	Yes
Changes in biomass carbon stocks	CO_2	Yes
Emissions from drained organic soils (combined with Land Converted to Grassland)	CO_2, CH_4, N_2O	No – not estimated
Land Converted to Grassland		
Changes in all carbon stocks	CO_2	Yes
Wetlands Remaining Wetlands		
Changes in carbon stocks in coastal wetlands	CO_2	Yes
Change in carbon stocks in inland wetlands	CO_2	Yes
Non-CO_2 emissions from wetlands	CH_4	Yes
Aquaculture	N_2O	No – not estimated
Land Converted to Wetlands		
Changes in carbon stocks in wetlands	CO_2	Yes
Non-CO_2 emissions from wetlands	CH_4	Yes
Settlements Remaining Settlements		
Changes in settlement tree carbon stocks	CO_2	Yes
Changes in yard trimming and food scrap carbon stocks	CO_2	For information only
Managed soils emissions	N_2O	Yes
Emissions from drained organic soils (combined with Land Converted to Settlements)	CO_2, CH_4, N_2O	Yes
Land Converted to Settlements		
Changes in all carbon stocks	CO_2	Yes
Other land remaining Other Land		
Changes in all carbon stocks	CO_2	No – not estimated
Land Converted to Other Land		
Changes in all carbon stocks	CO_2	No – not estimated

Category/subcategory name	Gas(es)	Included in the inventory[a]
Harvested Wood Products		
Change in carbon stock in products in use	CO_2	No – not estimated
Change in carbon stock in landfilled wood and paper	CO_2	For information only
Biomass burning		
Non-CO_2 emissions from wildfires (segregated by land type)	CH_4, N_2O	Yes
[a] Indicates categories that are included in the current inventory cycle based on availability of data and appropriate methods, will change over time; if not included, it will be noted if not estimated or not occurring. [b] Soil management (N_2O) emissions are included under the Agriculture sector.		

Inventory cycle

The NWL GHG inventory compilation cycle includes the steps outlined in Table 2. While this document is focused on the NWL sector, it should be taken in the context of the broader process for the compilation of the overall New Jersey GHG inventory for all sectors.

Table 2. General inventory cycle steps and corresponding activities

STEP	Activities
PLAN	• Develop a schedule, assign roles & responsibilities, agree on data sharing and archiving protocols, engage data suppliers (during the first inventory cycle, then adjust as needed) • Inventory inception meeting to signal all-hands-on-deck approach and build political support • Regular meetings of the core inventory team • Review the previous inventory, if available, make sure all archived data files are accessible • Review and implement improvement plan, considering prioritized cross-cutting and category-specific improvements • Develop QA/QC plan or review QA/QC findings from previous inventory cycle • Identify available activity data and choose corresponding methodologies for each category and/or subcategory, considering key categories • Create data and document archiving system
COLLECT	• Collect activity data, compile emission factors • Quality Control (QC) all data as part of the compilation process • Adjust methodology selection if needed based on data availability
CALCULATE	• Estimate emissions and removals • Implement QC procedures on estimations • Revise estimates based on new data and QC findings • Ensure time series consistency, recalculate previous estimates when new data/methods are used • Conduct uncertainty and key category analysis
WRITE	• Document methodological approaches, recalculations, and references • Write inventory report, including graphical illustrations of results
REVIEW	• Conduct internal and external QA reviews • Conduct final QC procedures • Solicit public comments • Address QA/QC findings
FINALIZE AND SUBMIT	• Finalize inventory • Develop inventory improvement plan

STEP	Activities
	• Publish/submit inventory
ARCHIVE	• Save all activity data and documentation on data processing • Save all compilation files and references to create an inventory archive • Backup archive

The timeline for the preparation of the NWL GHG inventory aligns with the state's GHG inventory cycle. The steps outlined in Table 2 generally occur sequentially, with QA/QC activities interspersed throughout. Planning occurs at the beginning of the cycle, with periodic check-ins with the team to ensure on-track preparation of the inventory. In the NWL sector, the interval between releases of updated activity data on NJ land use and land use change is approximately 5 years. This results in the need to interpolate data for the years in between for some of emission/removal categories. Methods and Data section of the SOP outlines approaches for estimating emissions for: estimating emissions for years when new data is available, estimating emissions for years before new data is available with some assumptions, and for recalculating emissions when the next new data set is released.

Institutional Arrangements

Institutional arrangements (IA) for a GHG inventory system include definitions of the roles and responsibilities associated with preparing a GHG inventory of emissions and removals, including which agencies and experts will compile the necessary data and information and the tasks they will perform. This section serves as a reference for current and future New Jersey State GHG inventory compilers and describes IAs for completing the New Jersey NWL inventory. An analogous set of arrangements may also be defined for the broader New Jersey GHG inventory.

Specifically, this section:

- Documents all parties involved in the inventory, and their roles and arrangements by sector or category
- Archives key contacts for activity data for each sector or category included in the New Jersey State NWL inventory
- Sets the inventory schedule and coordinates future inventories
- Assesses how existing institutional arrangements can be improved and documents the proposed improvements
- Informs new team members of existing arrangements

When necessary, details regarding how the arrangements were established are included.

Roles and responsibilities

The roles of the team implementing the NWL sector of the inventory are described below. One person may serve multiple roles in the inventory compilation cycle, however, it is important to have clear definitions regarding assigned roles so that best practices can be followed and appropriate resources are allocated.

- **NWL Inventory Coordinator**: Coordinates the preparation of the NWL sector of the state-wide GHG inventory, who is responsible for conducting the calculations and drafting the section of the report with the results. There may be additional leads for separate categories focusing specifically on a particular category. Additional leads coordinate with the sector leads on the preparation of calculations and reports for the corresponding portion of the inventory.
- **Archiving Coordinator**: Conduct archiving of the NWL inventory data and reports as part of the overall state GHG inventory archive
- **QA/QC Coordinator**: Lead the QA/QC of the NWL GHG inventory
- Uncertainty Analysis Coordinator: Lead the uncertainty analysis of the NWL GHG inventory
- **Key Category Analysis (KCA) Lead**: Conduct the KCA for the NWL GHG Inventory
- **New Jersey NWL Calculators Support**: Ensures the calculator reflects the latest methodology and all features function as designed
- **Inventory support**, by category: provides and/or processes activity data needed for inventory compilation
- **Expert reviewer(s):** external experts to review inventory calculations

For each category, roles and responsibilities of staff contributing to the NWL inventory are outlined in the Appendix. The role of expert reviewers in the quality assurance process are further detailed in the QA/QC section.

Data flows

The cross-cutting data flow of data needed to compile the NWL GHG inventory is described in Figure 1. Data flow diagrams specific to each land category will be provided in subsequent sections.

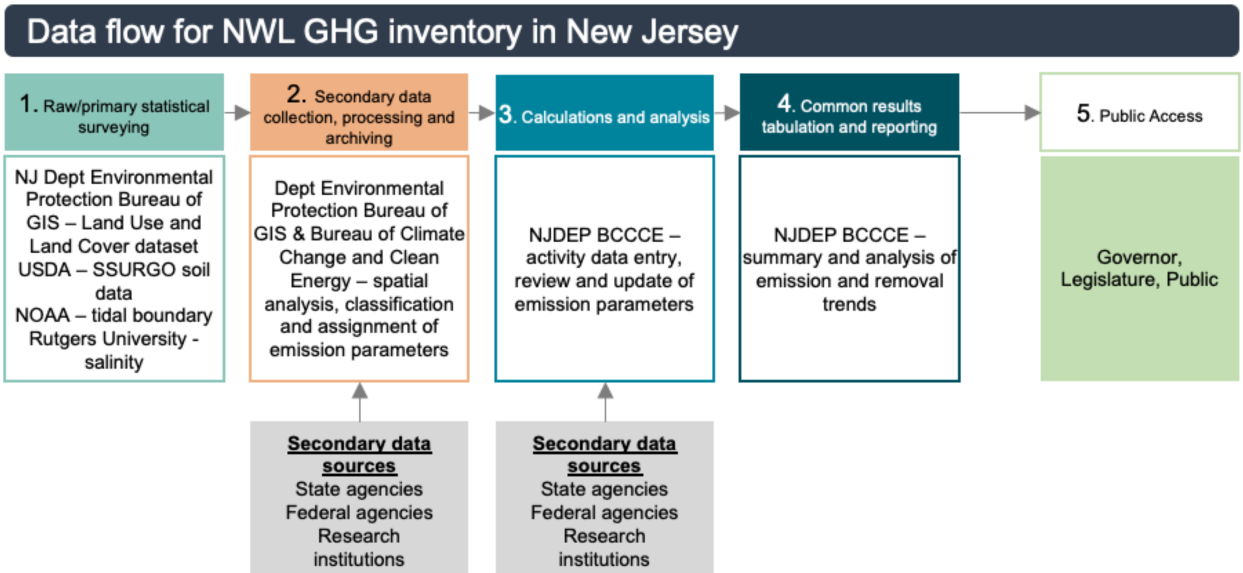

Figure 1. Data flow for Natural and Working Lands GHG inventory in New Jersey for consistent classification of lands across categories

Data sharing mechanisms

Currently, no formal data sharing arrangements exist to compile the state's NWL inventory. Although the majority of datasets used in the inventory are publicly available, activity data had to be identified and requested from agency staff. The spatial data used is primarily generated and managed by the Bureau of GIS within the NJDEP, which typically shares the land use data attribute table with the inventory compilation team when a new dataset is published and periodically updates extracts from national datasets such as soils data and tidal boundaries. Other non-spatial datasets, such as biosolid land application or waste generation, were obtained from public records available on the NJDEP websites and supplemented by follow-up discussions to obtain specific information. Furthermore, USDA-NASS was queried to obtain data on cropping and management information. As the inventory compilation team applied the methodology outlined below, formal data sharing mechanisms should be established to facilitate inventory compilation in the future.

GHG inventory improvements

This section documents improvements needed to strengthen institutional arrangements for each land use category (e.g., improve communication and coordination between institutions, establish agreements regarding data sharing, etc.).

Table 3 describes potential ways to improve institutional arrangements or establish new ones to address inventory needs, taking key categories and existing institutional arrangements within each sector into account. Improvements should be noted in Table 3 and also included in the IIP.

Table 3. Institutional arrangement improvements

Category	Potential improvement	Staff in charge of leading this improvement	Priority of improvement (Low, Medium, High)
Forest Land	Formalize sharing updated C density parameters between Forest Service and inventory compilers	TBD	TBD
Cropland	Conduct wider and more systematic engagement with the Dept of Agriculture to establish data collection processes	TBD	TBD
Grassland	Formalize sharing updated C density parameters between Forest Service and inventory compilers for shrubland	TBD	TBD
Wetlands	Formalize sharing updated emission parameters between Division of Science and Research and inventory compilers	TBD	TBD
Settlements	Conduct wider and more systematic engagement with staff dealing with wastewater and solid waste management to enable a more direct data sharing processes	TBD	TBD

Methods and Data

Overview

This section provides instructions on how to calculate emissions and removals for the categories in the NWL GHG inventory.

The development of the statewide NWL inventory requires multiple calculations and data processing steps. Tools and procedures utilized to support activity data collection and processing and enable the NWL GHG inventory compilation are outlined in this document. The SOP is accompanied by a series of Excel-based tools, named the New Jersey NWL calculators, which are to be used to compile activity data and parameters and perform emissions calculations after any necessary data processing is completed by other tools. The New Jersey NWL calculators and associated New Jersey NWL Calculator Manual are referenced throughout to guide the inventory compilation team. **Activity data** refers to information about the scale or magnitude of human activities that contribute to greenhouse gas (GHG) emissions or removals over a specific period (2006 IPCC Guidelines).

In subsequent sections, and for each category, users will be directed to conduct data processing or utilize specific parts of the calculator. For example, land imagery data will be retrieved, processed, documented, and analyzed for activity data that aligns with the chosen calculation method for a land type. Once activity data and other parameters are prepared for GHG estimates, users will be directed to NWL calculator to perform appropriate calculation steps.

Recommendations for improvement are identified and presented for the New Jersey inventory team to consider where appropriate, with a summary of improvements to inform the (IIP).

General methodological approach

The basis for estimating GHG emissions is taking activity data that represents activities associated with emissions or removals, and multiplying it by an appropriate emission factor or a set of emission parameters that represent emissions or removals associated with a given activity.

All GHG emissions and removals are reported in units of metric tonnes, tonne hereafter.

To calculate non-CO_2 emissions from land, for example, from biomass burning or managed soils, activity data is multiplied by an appropriate emission factor as indicated by the equation below:[3]

$$Emissions = AD \times EF$$

Where:

Emissions	= non-CO_2 emissions (*tonne for the non-CO_2 gas)*
AD	= activity data relating to the emissions source
EF	= emission factor for a specific gas and source category (*tonne per unit of AD)*

Calculations are conducted for each emission category and GHG, and can then be converted to units of carbon dioxide equivalent (CO_2e) based on each GHG's global warming potential (GWP).

For estimating emissions and removals from carbon stock changes, IPCC Guidelines provide two different approaches: the stock difference approach and a gain-loss approach. The **stock difference approach** is described by[4]:

$$\Delta C = \frac{C_{t_2} - C_{t_1}}{t_2 - t_1}$$

Where:

[3] 2006 IPCC Guidelines, Vol. 4, Ch. 2, Equation 2.6
[4] 2006 IPCC Guidelines, Vol. 4, Ch. 2, Equation 2.5

ΔC = annual carbon stock change in the pool *(tonne C year⁻¹)*

C_{t1} = carbon stock in the pool at time, t_1 *(tonne C)*

C_{t2} = carbon stock in the pool at time, t_2 *(tonne C)*

t_1 = time point 1, at which carbon stock is estimated *(year)*

t_2 = time point 2, at which carbon stock is estimated *(year)*

The stock-difference approach estimates carbon stock change in a given pool as an annual average difference between estimates at two points in time.

The **gain-loss approach** is a process-based approach described by[5]:

$$\Delta C = \Delta C_G - \Delta C_L$$

Where:

ΔC = annual carbon stock change in the pool *(tonne C $year^{-1}$)*

ΔC_G = annual gain of carbon *(tonne C $year^{-1}$)*

ΔC_L = annual loss of carbon *(tonne C $year^{-1}$)*

Estimating carbon stocks and fluxes also requires activity data and emission parameters appropriate to that carbon pool and ecological system. This document presents, for each category included in the NWL GHG inventory, the required activity data and emission parameters to estimate emissions or removals. The sections below detail activity data sources and processing steps, emission parameters and processing steps, as well as steps to take to enter them both into the New Jersey NWL calculator to complete the inventory.

The following carbon pools are considered when estimating C stocks and fluxes on land:

- Above-ground biomass (AGB)
- Belowground biomass (BGB)
- Dead wood (DW)
- Litter (LI)
- Soil organic carbon (SOC)
- Harvested wood products (HWP)

In some calculations, DW and LI are combined into a pool termed dead organic matter (DOM).

Land Use Definitions

To estimate GHG emissions and removals, all land must be classified and accounted for without duplications or omissions. The New Jersey inventory adopts a broad land use classification recommended by IPCC and also used in the National GHG Inventory (NGHGI).

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[5] 2006 IPCC Guidelines, Vol. 4, Ch. 2, Equation 2.4

New Jersey-specific definitions for classifying land are outlined below. It is assumed that all land in New Jersey is designated as managed land (Ogle, 2018).

Methodological approach

Choosing a methodological tier

The complexity of calculations depends on the availability of data which will determine the methodological tiers available for calculations of emissions and removal (2006 IPCC Guidelines, Vol. 4, Ch. 1, Box 1.1). Table 4 summarizes the IPCC's methodological tier structure and outlines trade-offs for their selection. Different tiers may be chosen for different sub-categories depending on data availability. Tiers can change over time as local data becomes available and more advanced methods are developed to improve estimate accuracy.

Table 4. IPCC Guidelines tiers and trade-offs and considerations when determining the calculation method.

Tier	Methodological description	Trade-offs and considerations
1	Employs default emission factors and default estimation methods, available in IPCC guidelines	Simplest to use, not location-specific; may not be sufficient to capture mitigation efforts of some activities; is generally less accurate than the results under the other tiers.
2	May use the same methodologies as Tier 1, or country or state-specific methodologies where proven to be more accurate than IPCC default parameters; applies emission factors and parameters based on location-specific data	Requires national or state data and research results to justify methodological decisions; estimates reflect location-specific ecosystem characteristics and climatic regions; should be used for key categories.
3	Employs empirical or process-based estimation models to estimate or predict GHG emissions	More sophisticated and complex, requiring detailed and long-term data, high levels of human and financial resources to develop models and bodies of literature to underpin modelling; provides greater accuracy for estimates and levels of uncertainty.

Cross-cutting activity data

Activity data represents a quantitative level of activity that leads to emissions or sequestration of GHGs. Activity data on land use and soil classifications apply to all land use categories and are described below. Some activity data, such as the amount of fertilizer applied or waste generated, is applicable only for specific emission categories and are described in the associated sections.

Land classification

GHG inventory for the natural and working land includes land categories following the IPCC guidelines (IPCC 2006). The IPCC defines six main land-use categories: **Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Lands**. These categories are designed to classify all lands without duplication. The land classifications utilized by the NJDEP Bureau of GIS Land Use Land Cover (NJ LULC) dataset were mapped to these six (6) broad categories as outlined below.

Anderson Land Classification

The NJ LULC dataset uses remote sensing data and tracks land use changes between consecutive land use maps, following a modified Anderson classification, which includes 86 land use classes (USGS Professional Paper 964, 1976). The classification provides a standardized framework for classifying land based on use and cover and has four (4) classification levels, from landscape-level data at Level I to detailed sub-classes codified by Level IV (Refer to Table 5 for the list of Level I classes). This classification has been modified to New Jersey's context.

Datasets for 1986, 1995, 2002, 2007, 2012, 2015, and 2020[6] are currently available and utilized in preparation of the 2024 New Jersey GHG inventory.

Table 5. Anderson Level I classification utilized by New Jersey in the NJ LULC dataset

Anderson Land Code	Landscape Type
1000	Urban or Built-up Land
2000	Agricultural Land
3000	Rangeland – not found in New Jersey, therefore omitted from state classification
4000	Forestland
5000	Water
6000	Wetlands
7000	Barren Land

IPCC Land Classification

These land use classes are mapped into six (6) IPCC land use classes to account for different land uses, cover, and physiography, as shown in Table 6.[7] Since the land classification for GHG inventory focuses on accounting for changes in carbon pools and other emission sources, the land categorization relevant for GHG accounting is expected to have differences from the Anderson classification, which is intended for land use planning and ecological management. For example, land without vegetation, such as confined feeding operations, even though clearly intended for agricultural purposes, would be categorized under *Other Land* because it lacks vegetation and more closely resembles barren land in terms of relevant carbon pools. Similarly, some of the categories under *Urban or Built-up Land* (level 1000) would be included under *Wetlands* because, as defined by the Anderson classification, they may still have wet or saturated soils.

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[6] As of May 2025, year of the dataset represents the year that imagery data was acquired.

As the Anderson classification is broadly accepted and widely utilized in New Jersey, resulting in historical datasets and future updates, the NJ LULC dataset was selected as the primary activity data source for the purposes of the NJ GHG inventory.

Table 6. Mapping of New Jersey land classes to IPCC categories

IPCC land category	Anderson code	New Jersey Anderson land category
Forest land	4110	Deciduous forest (10-50% crown closure)
	4120	Deciduous forest (>50% crown closure)
	4100*	Deciduous forest – allocated to Deciduous forest (>50% crown closure) (4120)
	4210	Coniferous forest (10-50% crown closure)
	4220	Coniferous forest (>50% crown closure)
	4200*	Coniferous forest – allocated to Coniferous forest (>50% crown closure) (4220)
	4321	Mixed forest (>50% deciduous with 10-50% crown closure)
	4322	Mixed forest (>50% deciduous with >50% crown closure)
	4320*	Deciduous/coniferous forest – allocated to Mixed forest (>50% deciduous with >50% crown closure) (4322)
	4311	Mixed forest (>50% coniferous with 10-50% crown closure)
	4312	Mixed forest (>50% coniferous with >50% crown closure)
	4310*	Coniferous/deciduous forest – allocated to Mixed forest (>50% coniferous with >50% crown closure) (4312)
	4230	Plantation
	4500	Severe burned upland vegetation
Cropland	2100	Cropland and pastureland
	2200	Orchards/Vineyards/Nurseries/Horticultural areas
	2260*	Cranberry bogs – allocated to Orchards/Vineyards/Nurseries/Horticultural areas (2200)
Grassland	4410	Old field (< 25% brush covered)
	4420	Deciduous brush/shrubland
	4430	Coniferous brush/shrubland
	4440	Mixed deciduous/coniferous brush/shrubland
	4400*	Brushland/shrubland – allocated to Mixed deciduous/coniferous brush/shrubland (4440)
Wetlands	1461	Wetland rights-of-way
	1741	Phragmites dominate urban area
	1750	Managed wetland in maintained lawn greenspace
	1850	Managed wetland in built-up maintained rec area
	2140	Agricultural wetlands (modified)
	2150	Former agricultural wetland (becoming shrubby, not built-up)
	4411	Phragmites dominate old field
	5100	Streams and canals
	5190	Exposed flats
	5200	Natural lakes
	5300	Artificial lakes
	5410	Tidal rivers, inland bays, and other tidal waters
	5411	Open tidal bays
	5412	Tidal mud flat
	5420	Dredged lagoon
	5430	Atlantic Ocean
	6110*	Saline marsh – allocated to Saline marsh (low marsh) (611)
	6111	Saline marsh (low marsh)

IPCC land category	Anderson code	New Jersey Anderson land category
	6112	Saline marsh (high marsh)
	6120	Freshwater tidal marshes
	6141	Phragmites dominate coastal wetlands
	6210	Deciduous wooded wetlands
	6220	Coniferous wooded wetlands
	6221	Atlantic white cedar wetlands
	6231	Deciduous scrub/shrub wetlands
	6232	Coniferous scrub/shrub wetlands
	6233	Mixed scrub/shrub wetlands (deciduous dom.)
	6234	Mixed scrub/shrub wetlands (coniferous dom.)
	6240	Herbaceous wetlands
	6241	Phragmites dominate interior wetlands
	6251	Mixed wooded wetlands (deciduous dom.)
	6252	Mixed wooded wetlands (coniferous dom.)
	6290	Unvegetated flats
	6500	Severe burned wetland vegetation
	7430	Disturbed wetlands (modified)
	7440	Disturbed tidal wetlands
Settlements	1110	Residential, high density or multiple dwelling
	1120	Residential, single unit, medium density
	1130	Residential, single unit, low density
	1140	Residential, rural, single unit
	1100*	Residential – allocated to Residential, single unit 1140
	1150	Mixed residential
	1200	Commercial/services
	1211	Military installations
	1214	No longer military
	1300	Industrial
	1400	Transportation/communication/utilities
	1410	Major roadway
	1411	Mixed transportation corridor overlap area
	1420	Railroads
	1440	Airport facilities
	1462	Upland rights-of-way developed
	1463	Upland rights-of-way undeveloped
	1499	Stormwater basin
	1500	Industrial and commercial complexes
	1600	Mixed urban or built-up land
	1700	Other urban or built-up land
	1710	Cemetery
	1711	Cemetery on wetland
	1800	Recreational land
	1804	Athletic fields (schools)
	1810	Stadium, Theaters, Cultural Centers, and Zoos
	2400	Other agriculture
	7500	Transitional areas
Other land	2300	Confined feeding operations
	6130	Vegetated dune communities

IPCC land category	Anderson code	New Jersey Anderson land category
	7100	Beaches
	7200	Bare exposed rock, rock slides, etc.
	7300	Extractive mining
	7400	Altered lands
	7600	Undifferentiated barren lands
*** Indicates categories that have been used in the past (prior to 1995) and are no longer utilized. For consistency, acreage from old categories was allocated to analogous categories.**		

The category below is excluded from the mapping because it contains no carbon reservoirs or emission sources and likely overlaps with area accounted for under the Wetlands subcategories representing water bodies:

- Bridge over water (1419)

The proposed categorization is subject to review and revision.

The sub-classes of land within each of the main categories may remain disaggregated to allow for the application of relevant and more refined emission calculation parameters if available. Otherwise, the areas of these different sub-classes are aggregated to estimate GHG removals/emissions. The methodology for each land category outlined below provides a more detailed description of the sub-class groupings within each category.[8]

Land Remaining Land & Land Converted to Another Land

For GHG accounting purposes, each land-use category is further subdivided into land remaining in that category (e.g., forest land remaining forest land) and land converted from one category to another (e.g., cropland converted to forest land) as shown in Figure 2. The New Jersey NWL calculators are set up to enable area of land remaining in the same category and land converted to a new category as shown in the NJ NWL Calculator Manual (Section: Basics of Data Entry).

[8] If methodology and/or relevant emission parameters are not available to estimate emissions for some of the sub-classes, they may be aggregated until additional information becomes available and allows further disaggregation.

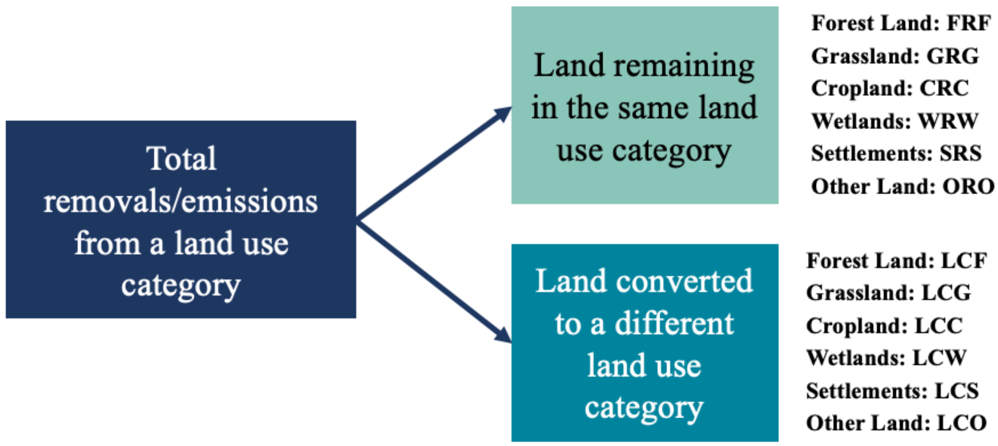

Figure 2. Categorization of land use types for the purpose of estimating total GHG emissions and removals. FRF = Forest Land Remaining Forest Land, etc., LCF = Land converted to Forest Land, etc.

Land converted to another land category is further subdivided into categories based on the land category prior to transition, e.g., cropland converted to forest land, grassland converted to forest land, and so on. Emissions and removals are estimated for each of these subcategories. The total emissions/removals for each land use category are the sum of those from the land remaining and land converted subcategories. This subcategorization is utilized to account for the transitional period when land is converted and has differing characteristics compared to land remaining in the same category. For example, land converted to forest land, where young trees are planted, will have higher carbon accumulation rates in biomass than a mature forest. Likewise, soil organic carbon also takes time to reach a new equilibrium after management changes.

The IPCC guidelines recommend the default transition period to be 20 years. Land in the *remaining* category is land that has been in that category for at least 20 years. When land transitions to a new category, it is kept in the *converted* category for 20 years.

Currently, the NJ LULC datasets provide information on land category transitions; however, they are not tracked over a 20-year period, only compared to the previous dataset, where the interval is 3-9 years, about 5 years on average. For the inventory, using existing NJ LULC datasets (up to 2020):

- Land area that has the same classification in consecutive datasets is categorized as **land remaining in the same category**.
- Land area that changed classification in the period between two consecutive datasets is categorized as **land converted to a different land use category** for the year that the latter of the two datasets was collected.

Data is aggregated to obtain the area of land remaining the same and converted to each land category, as demonstrated schematically in Figure 3.

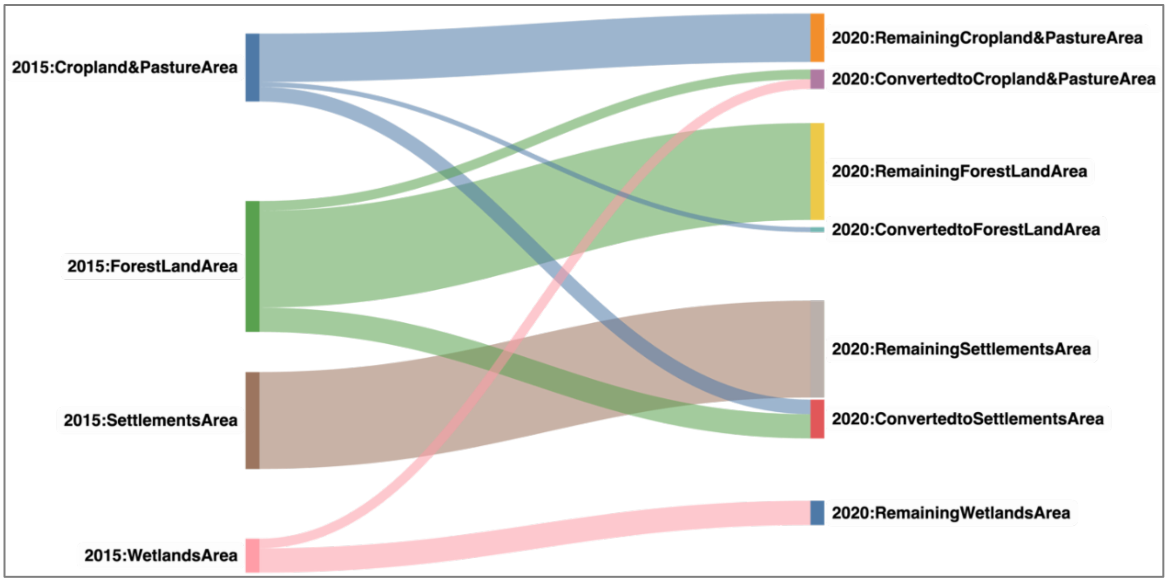

Figure 3. Tracking land transitions – example showing land converted between categories from 2015 to 2020.

Data products associated with the NJ LULC dataset currently do not provide information on land use transitions over a 20-year period; rather, they analyze change only from the previously published dataset. For this inventory (covering years 1990-2024), area of land in remaining and converted sub-categories were based on the two consecutive datasets even if the interval between them is less than 20 years.

To prepare the activity data from the NJ LULC datasets, the LULC data is joined with data on **soils**, **elevation**, and **salinity** to ensure consistency, enable adjustments, and reduce errors for all land categories before disaggregating data into the main land categories used in the NWL GHG Inventory. Data processing steps will be conducted by the Bureau of Climate Change and Clean Energy (BCCCE) and the Bureau of GIS (BGIS) and outlined in detail in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning). Processed data is then entered into the New Jersey NWL Calculators according to the steps outlined in the NJ NWL Calculator Manual (see land category specific sections).

Additionally, land category specific data preparation approaches are further discussed in each land category sections, as appropriate. Activity data is to be added when new NJ LULC datasets are released, which is approximately every 5 years.

For the years where data is not available, linear extrapolation between 2 known dataset years is used. The New Jersey NWL Calculators will automatically calculate and fill in existing data gaps.

For years when there is no updated dataset, it is assumed that the areas of land categories remain unchanged, so the same areas as in the last available published dataset are used to estimate GHG emissions/removals. They are automatically filled in by New Jersey NWL Calculators until data is entered for the year when an update becomes available (see Table 7).

For years when there is an updated dataset, data is aggregated according to the method described in this section and the areas are entered into the calculator. The areas between the most recent and prior datasets are automatically extrapolated and updated. GHG emissions and removals are also automatically recalculated for the time period between the most recently released updated dataset and the previous one (see Table 7).

Table 7. Filling in missing data before and after an updated land use dataset is published, forest land example.

	2020 LULC dataset	Extrapolated Inventory Data		
		2021	2022	2023
Forest Land Remaining Forest Land	1000	1000	1000	1000
Land Converted to Forest Land	100	-	-	-

	2020 LULC dataset	Interpolated Inventory Data				2025 LULC dataset
		2021	2022	2023	2024	
Forest Land Remaining Forest Land	1000	980	960	940	920	900
Land Converted to Forest Land	100	30	60	90	120	150

Each category requires accounting for changes in relevant carbon pools and non-CO_2 emission sources, the methodology for which is outlined below for each category. Methodological approaches are based on IPCC Guidelines and the National GHG inventory (NGHGI). US EPA, as an agency responsible for the preparation of the NGHGI, also disaggregates the data at the state level. Furthermore, US EPA developed the State Inventory Tool (SIT), which also allows the states to leverage disaggregated state-level data. For some of the categories discussed below, utilizing the disaggregated state-level data or SIT outputs may be the most feasible approach to estimate the emissions contribution from that category.

Soil classification and SOC reference values

The USDA Soil Survey Geographic Database (SSURGO) will be used to classify soil order into mineral soils and obtain reference soil organic carbon (SOC) stock values unless otherwise specified. Among soil types, textures, and other attributes, SSURGO provides SOC values at various depths. The default soil depth used in the IPCC Guidelines is 30 cm. SOC values at 30 cm depth will be used as reference for mineral soils for all land categories unless otherwise noted, in particular for some land use transitions related to wetlands, where reference SOC within a 1m depth soil horizon is used. This dataset contains data collected via surveys and measurements over an extended period and is refreshed annually on July 1st. New Jersey is located in the warm temperate moist climate zone, according to the IPCC climate zone classification (Ogle, 2006). SOC reference values were determined for mineral and organic soils by averaging SOC across mineral and organic taxonomic orders, respectively (Table 8). The steps to download and prepare the data are outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning).

Table 8. Soil classifications and SOC reference values at 30cm and 1m depth, derived from SSURGO data (Reference: SSURGO, 2025)

Soil types	USDA taxonomic order	Average SOC_{ref} 30cm depth (tonnes C hectare^{-1})	Average SOC_{ref} 30cm depth (tonnes C acre^{-1})	Average SOC_{ref} 1m depth (tonnes C hectare^{-1})	Average SOC_{ref} 1m depth (tonnes C acre^{-1})
Mineral	Vertisols, Mollisols, Inceptisols, Aridisols, Alfisols Ultisols, Oxisols, Entisols, Andisols, Spodisols	45.9	18.58	75.0	30.35
Organic	Histosols	218.5	88.42	687.0	278.02

Soil carbon stock changes factors and emission factors

Soil organic carbon stock changes when land management changes or when land transitions to a new land category. For example, in cropland, if agricultural fields go from conventional tillage to a reduced or no-till regime, carbon accumulates in soil over time. For mineral soils, IPCC's default assumption is that it takes 20 years to reach a new equilibrium from the time management changed. For organic soils, when drained, the assumption is that C losses continue forever. Default emission parameters (Tier 1) provided by IPCC Guidelines will be used to estimate soil organic carbon fluxes for mineral and organic soils, with relevant parameters provided for each land category.

Annual Change in Organic Carbon Stocks in Mineral Soils

When land is stratified and parameters are selected, the change in soil carbon stock in mineral soils can be calculated using Equation 1 (2019 Refinement to 2006 IPCC GL, Vol. 4, Chap. 2, Eq. 2.25). This is applicable for lands remaining in the same land category when there are changes in management and for lands converted to other categories by applying the appropriate land use stock change factor. Detailed application of this equation will be outlined in each category.

Equation 1. Annual change in carbon stocks in mineral soils

$$SOC = \sum_{c,s,i} SOC_{REF\ c,s,i} \times F_{LU\ c,s,i} \times F_{MG\ c,s,i} \times F_{I\ c,s,i} \times A_{c,s,i}$$

$$\Delta C_{Mineral} = \frac{SOC_0 - SOC_{0-t}}{D}$$

$\Delta C_{Mineral}$: Annual change in carbon stocks in mineral soils (tonne C year^{-1})

SOC_0: Soil organic carbon stock in the last year of an inventory time period (tonne C)

$SOC_{(0-t)}$: Soil organic carbon stock at the beginning of the inventory time period (tonne C)

Note: SOC_0 and $SOC_{(0-t)}$ are calculated using the SOC equation above, where the reference carbon stocks and stock change factors are assigned based on land-use, management activities, and corresponding areas at each point in time (time = 0 and time = 0–T).

T: Number of years over a single inventory time period (years); T is used in place of D in this equation if T is ≥ 20 years, see note below

D: Time dependence of stock change factors — the default time period for transition between equilibrium SOC values (years). Commonly 20 years, but the value depends on assumptions made when computing F_{LU}, F_{MG}, and F_I. If T exceeds D, use T to compute the annual rate of change for the period 0–T.

c: Climate zones

s: Soil types

i: Set of management systems present in the state

SOC_{REF}: Reference carbon stock (tonne C hectare^{-1})

F_{LU}: Stock change factor for land-use systems or subsystems (dimensionless)

F_{MG}: Stock change factor for management regime (dimensionless)

F_I: Stock change factor for input of organic matter (dimensionless)

A: Land area of the stratum being estimated (hectares). The stratum should have consistent biophysical conditions (climate, soil type) and a shared management history over the inventory period to be analytically valid.

Due to how New Jersey currently collects data on land use, which does not allow tracking the 20-year transition, the estimates of SOC fluxes will assume that the change in SOC stock occurs in the year of the transition, i.e.,

Equation 1, when applied, D will be equal to 1. C is converted to CO2 by multiplying by (44/12).

Units

All GHG emissions and removals are reported in units of metric tonnes of each individual GHG, tonne hereafter. Furthermore, all data entered in the New Jersey NWL calculators must be in acres as the area units. Acres is also the unit used in the NJ LULC source dataset.

Emission parameters are provided in this document both in the units they were originally measured and published and in the unit of tonne acre^{-1} or tonne acre^{-1} year^{-1} as they appear in the calculator. Additional conversion steps are noted where needed. The following conversions are commonly used:

- 1 acre = 2.47 hectare
- 1 dry short ton = 0.907 metric tonne
- 0.5 = fraction of C in biomass

Conversion factors

The following conventions and conversions will be used in the inventory estimates:

- Negative values = net removals (i.e., from atmosphere)
- Positive values = net emissions (i.e., to atmosphere)

In greenhouse gas inventories, carbon dioxide (CO_2) emissions, in particular, when quantifying carbon fluxes are first quantified in terms of the mass of carbon (C) alone. However, for reporting purposes, emissions must be expressed as the full CO_2 molecule, which includes both carbon and oxygen atoms. To convert from C to CO_2, a molecular weight ratio is applied: the molecular weight of CO_2 (44 g/mol) divided by the molecular weight of carbon (12 g/mol). This ratio (44/12) accounts for the additional mass contributed by the oxygen atoms, ensuring that reported emissions reflect the total molecular mass of carbon dioxide rather than just the carbon content.

- C to CO_2 conversion: 1 CO_2 = 44/12 x C

Nitrous oxide (N_2O) emissions are often first estimated and expressed in terms of nitrous oxide–nitrogen (N_2O–N), which represents only the nitrogen component of the N_2O molecule. However, for reporting in a GHG inventory, emissions must be reported as the full N_2O molecule, which includes both nitrogen and oxygen atoms. To convert from N_2O–N to N_2O, a molecular weight ratio is applied: the molecular weight of N_2O (44 g/mol) divided by the molecular weight of the nitrogen atoms it contains (28 g/mol). This ratio (44/28) accounts for the additional mass contributed by the oxygen atoms, ensuring that reported emissions reflect the total molecular mass of nitrous oxide rather than just its nitrogen fraction.

N_2O–N to N_2O conversion: 1 N_2O = 44/28 *x* N_2O–N

The New Jersey NWL calculators automatically implement these conversions.

Global Warming Potential

Non-CO_2 emissions need to be converted to CO_2 equivalent (CO_2e) using their associated Global Warming Potential (GWP). As default, the 100-year time horizon values from the IPCC Fifth Assessment Report (AR5) will be used in the calculator. Values are tabulated in Table 9. Global Warming Potential values will be easily adjustable in the calculator tool should the inventory team choose other values for consistency, time horizon considerations, or future updates. The New Jersey NWL Calculators allow users to select GWP to be applied and automatically convert non-CO_2 emissions to units of CO_2e in the emissions summary tab of each calculator.

Table 9. GWP values provided in the New Jersey NWL calculators

IPCC Assessment Report	Methane (CH_4)		Nitrous Oxide (N_2O)	
	20-year	100-year	20-year	100-year
2007 IPCC Fourth Assessment Report (AR4)	72	25	289	298
2014 IPCC Fifth Assessment Report (AR5)	84	28	264	265
2021 IPCC Sixth Assessment Report (AR6)	81.2	27.9	273	273

Uncertainty

Uncertainty is a fundamental consideration in greenhouse gas inventories. The accuracy of emission and removal estimates relies on the quality of activity data, the accuracy of emission factors, and the extent to which all relevant land categories are stratified and characterized. The IPCC guidelines provide default values and Tier 1 methodologies to enable entities, regardless of data availability, to produce reliable estimates. However, it is good practice to use location-specific data and derive emission parameters that reflect local conditions, allowing the application of higher-tier methods wherever possible, in order to reduce uncertainty and improve the accuracy and transparency of the greenhouse gas inventory. IPCC Guidelines also emphasize the need for continuous improvement in data collection, reporting, and methodological refinement. This involves documenting sources of uncertainty, prioritizing data collection in areas with the greatest gaps, and recalculating historical inventories when new methods or data become available, in order to maintain consistency in time series.

Each section below outlines the main sources of uncertainty to be considered and recommended improvements. The IIP provides a compilation of all the improvements and prioritizes them based on the needs of the state and Key Category Analysis results.

Future improvements

Currently, land transitions are not tracked over a 20-year period as recommended by IPCC guidelines. This treatment may lead to both over- and underestimation of emissions and removals. For example, if recently reforested area is classified as mature forest before it is actually mature, the accumulation of carbon in biomass may be underestimated because the young trees grow faster than mature trees. On the other hand, soil carbon losses continue when cropland is developed over a 20-year period, but only a fraction of that would be accounted for. Therefore, it is recommended that the BGIS, the unit responsible for producing the NJ LULC datasets collaborate with the GHG inventory team to develop a system for processing data in a way that enables tracking of land transitions over a 20-year period.

Additionally, SOC reference value for mineral soils can be disaggregated and determine for the mineral soil classifications aligned with IPCC methodology (2006 IPCC GL, Vol. 4, Chap. 3, Figure 3A.5.3) to have distinct SOC reference values for different types of mineral soils such as high activity clay, low activity clay, sandy, spodic, volcanic, and wetland mineral soils.

FOREST LAND

Forest land definitions

The amount of CO_2 removed from the atmosphere by forests varies greatly by forest growth rate. Younger trees grow faster, thus removing more CO_2 per unit area per year which gradually decreases as they mature. Therefore, land converted into forest land from non-forest land and younger forests will sequester more CO_2 due to trees growing faster than mature forests of the same type. The following categories are accounted for in the Forest Land category:

- Carbon fluxes in Forest Land remaining Forest Land (by carbon pool)
- Carbon fluxes in Land Converted to Forest Land (by carbon pool)

The following carbon pools are considered when estimating C stocks and fluxes in forest lands:

- Above-ground biomass (AGB)
- Belowground biomass (BGB)
- Dead wood (DW)
- Litter (LI)
- Soil organic carbon (SOC) – mineral soils
- Soil organic carbon (SOC) – organic soils
- Harvested wood products (HWP)

C pools for which estimates are provided depend on data availability and further detailed below.

Organic soils, i.e., soils with histosols taxonomic order, in forest land are identified separately from other forest land soils largely because mineralization of the exposed or partially dried organic material results in continuous CO_2 and N_2O emissions (IPCC 2006). In addition, the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014) calls for estimating CO_2, CH_4, and N_2O emissions from organic soils and the ditch networks used to drain them if drainage is occurring. Drained organic soils are further characterized by drainage or the process of artificially lowering the soil water table, which exposes the organic material to drying and the associated emissions. Due to data gaps, emissions from drained organic soils are not estimated, but anecdotal evidence suggests that drainage does occur.

Non-CO_2 emissions from biomass burning – CH_4 and N_2O – are estimated and reported separately. CO_2 emissions from biomass burning are reported for information, but not counted as losses of carbon stock are already accounted for by fluxes in other carbon reservoirs. See Biomass Burning section for emissions estimation methodology for this source category.

Nitrous oxide (N_2O) emissions due to application of nutrients on Forest Lands are not occurring in New Jersey.

The estimates for HWP C fluxes are provided for information only.

Data flows for compiling emission and removal estimates for Forest Lands are shown in Figure 4.

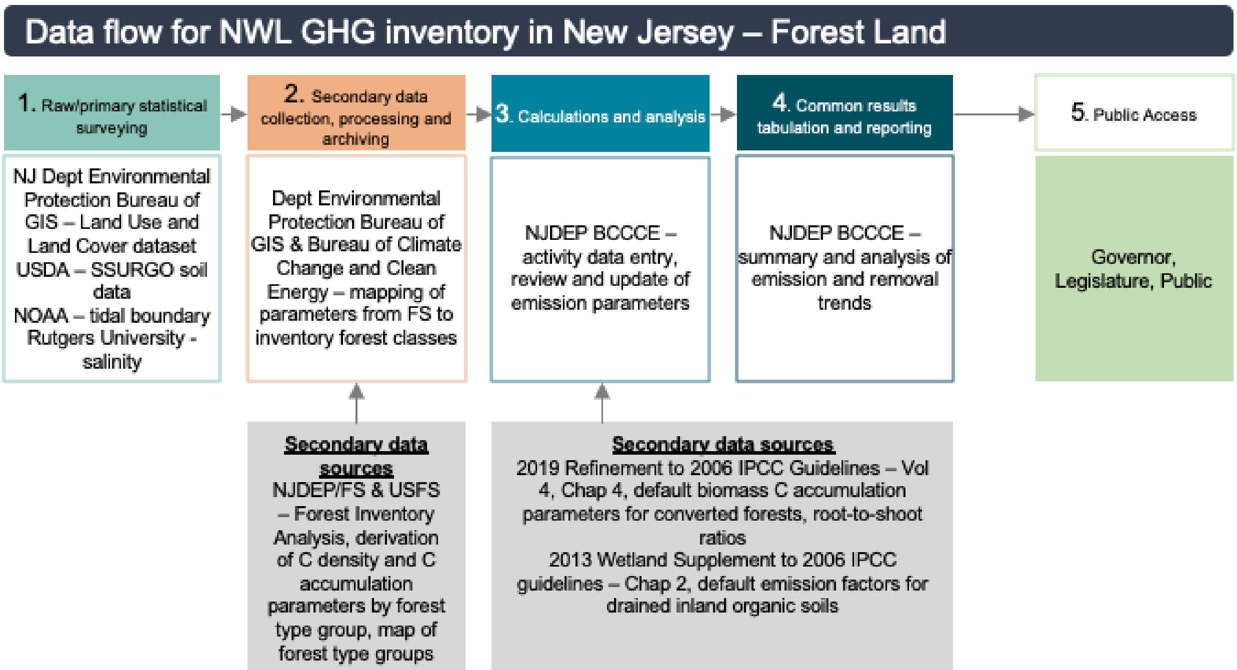

Figure 4. Data flow for NWL GHG inventory in New Jersey for the Forest Land category

Activity data

Land area

New Jersey maintains a dataset for land use and land cover described above in the section on general activity data. Forest Land category includes 10 subclasses based on vegetation type and crown cover, which include:

1. Coniferous forest, >50% crown closure
2. Coniferous forest, 10-50% crown closure
3. Deciduous forest, >50% crown closure
4. Deciduous forest, 10-50% crown closure
5. Mixed forest, >50% coniferous with >50% crown closure
6. Mixed forest, >50% coniferous with 10-50% crown closure
7. Mixed forest, >50% deciduous with >50% crown closure
8. Mixed forest, >50% deciduous with 10-50% crown closure
9. Plantation
10. Severe burned upland vegetation

For each year when an updated LULC dataset is available, forest land area for each of the categories is prepared according to the steps outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning) and disaggregated by remaining and converted to forest. For land converted to forest lands is further disaggregated by land category from which it was converted to enable of estimating of C fluxes and non-CO_2 emissions, as appropriate. All data entered in the New Jersey Forest Land calculator must be in acres as the area units. Acres is also the unit from the source dataset. Therefore, no conversions are necessary. For step by step instructions see the NJ NWL Calculator Manual (Section: Forest Land Calculator/Land Area 1-6).

Stratification by soil type

All forest lands (remaining and converted) are disaggregated by soil taxonomic order into mineral or organic soils. Data on taxonomic order was taken from the USDA SSURGO dataset (retrieved May 2025). See cross-cutting section for the steps on data preparation and processing. Area of forest land occurring on mineral and organic soils is entered as activity data following instructions in the NJ NWL Calculator Manual (Section: Forest Land Calculator/Land Area 7-8).

Soil organic carbon (SOC) fluxes occur due to changes in management and land conversion. For forest land remaining forest land, SOC flux is assumed to remain in equilibrium and therefore, not estimated. For land converted to forest, occurring on mineral soil, SOC fluxes are estimated using approach described in the cross-cutting section (see Equation 1). Emissions from organic soils are not estimated due to lacking of data on the proportion of land that is drained, however activity data for area of forest on organic soils is entered to allow future calculations.

Emission parameters

Forest Remaining Forest

Biomass Carbon density and accumulation rates

A network of periodic and annual national forest inventory (NFI) plots established and measured by the Forest Inventory and Analysis (FIA) program within the USDA Forest Service is the primary data source for emission parameters. Carbon density and accumulation parameters are derived for all carbon pools in the forest land based on data from the FIA program data. New Jersey FIA plots are remeasured every 5 years and provide C measurement data for relevant carbon pools for forest type groups occurring in New Jersey.

FIA data is queried using the USFS EVALIDator website (https://apps.fs.usda.gov/fiadb-api/evalidator) to obtain data on C density for the five carbon pools for which the data is collected: live aboveground, live belowground, deadwood, litter, and soil organic carbon using parameters listed in Table 10. Data is downloaded as a .CSV file to obtain total carbon density by forest type group.

Table 10. Carbon density query parameters for EVALIDator to derive carbon density parameters for relevant carbon pools

EVALIDator Selection Parameters	User Selection
Land basis	Forest land
Numerator estimation group	Carbon
Denominator estimation group	Area
Press continue	
Numerator attribute number and description: Note: Five files must be downloaded separately for each of the carbon pools. Follow all steps to obtain the tabular parameters.	0103 Forest carbon total: all 5 pools, in metric tonne, on forest land OR 0098 Forest carbon pool 1: live aboveground, in metric tonne, on forest land 0099 Forest carbon pool 2: live belowground, in metric tonne, on forest land 0100 Forest carbon pool 3: deadwood, in metric tonne, on forest land 0101 Forest carbon pool 4: litter, in metric tonne, on forest land 0102 Forest carbon pool 5: soil organic, in metric tonne, on forest land
Denominator attribute number and description	0002 Area of forest land, in acres
Forest land definition	FIADEF
Inventories	Show all available inventories
Press continue	
State/EVAL_GRP(s)	New Jersey 342022 (current inventory 2018-2022)
Press continue	
Page variable	None
Page temporal basis:	Current
Row variable	Forest type group (based on values from the Current inventory)
Row temporal basis:	Current
Column variable	Ownership group - Major (based on values from the Current inventory)
Column temporal basis:	Current
Output format	Download normalized estimates in CSV

The carbon density values from FIA are summarized in Table 11. These are used to derive emission parameters for the Anderson classes used in the activity data as described in the NJ NWL Calculator Manual (Section: Data collection, processing, and cleaning/Third party datasets 5).

Table 11. New Jersey forest type group carbon densities for estimating carbon stocks and fluxes in forest land remaining forest land (Reference: US Forest Service, FIA, 2025)

Forest type group	**Carbon density (tonne C acre^{-1})**				
	AGB	BGB	DW	LI	SOC*
White/Red/Jack pine group	38.6 ± 13.3	7.4 ± 2.7	7.4 ± 3.4	7 ± 1.4	49.9 ± 10.9
Loblolly/shortleaf pine group	23.5 ± 1.6	4 ± 0.3	5 ± 0.4	7.4 ± 0.1	46.2 ± 1
Other eastern softwoods group	9.3 ± 6.6	1.6 ± 1.2	5 ± 2.4	4.9 ± 1.2	48.1 ± 6.1
Oak/pine group	28.2 ± 3.7	5 ± 0.8	6.2 ± 0.9	7.1 ± 0.2	47.6 ± 2.5
Oak/hickory group	38.1 ± 2.1	6.6 ± 0.4	8.6 ± 0.5	6.9 ± 0.2	52.8 ± 1.4
Oak/gum/cypress group	29.2 ± 3.5	5.1 ± 0.7	7.2 ± 1	6.8 ± 0.2	53 ± 1.9
Elm/ash/cottonwood group	19.4 ± 4.4	3.5 ± 0.8	5.8 ± 1.9	5.4 ± 0.5	57.2 ± 3.5
Maple/beech/birch group	30.7 ± 3.6	5.4 ± 0.6	7.5 ± 1.2	6.5 ± 0.3	52.9 ± 2.9
Aspen/birch group	22 ± 19.4	3.8 ± 3.4	5.5 ± 4.4	6.7 ± 1.6	53.6 ± 8.8
Other hardwoods group	35.7 ± 11.8	6.5 ± 2.2	10.2 ± 4.3	7.4 ± 1.2	67.3 ± 4.8
Nonstocked	3.7 ± 1.2	0.6 ± 0.2	5.9 ± 3.1	4 ± 0.4	53.1 ± 5.6
*SOC provided for information only, not used in the calculator. ± value represents the 95% confidence interval					

Carbon accumulation rates are generated for aboveground biomass and below ground biomass carbon pools in the forest land based on data from the network of periodic and annual FIA plots established and measured by the FIA program within the USDA Forest Service. FIA plots collected from the state of New Jersey will be used for estimating carbon density and carbon accumulation rates. New Jersey FIA plots are remeasured every 5 years and provide C measurement data for relevant carbon pools for forest type groups occurring in New Jersey. The values are similarly obtained using the EVALIDator website query carbon density values from the forest inventory using the EVALIDator website with the parameters listed in Table 12. Note that biomass dry matter measurements are reported in units of dry short tons, therefore a conversion from biomass to C (0.5 = fraction of C in biomass) and to tonnes (1 dry short ton = 0.907 metric tonne) is needed.

Table 12. Carbon accumulation query parameters for EVALIDator to derive carbon accumulation parameters for relevant carbon pools

EVALIDator Selection Parameters	User Selection
Land basis	Forest land
Numerator estimation group	Annual net growth dry weight
Denominator estimation group	Area change total
Press continue	
Numerator attribute number and description Note: Two files must be downloaded separately for each of the carbon pools. Follow all steps to obtain the tabular parameters.	311 Average annual net growth of aboveground biomass of trees (at least 1 inch d.b.h./d.r.c.), in dry short tons, on forest land OR 317 Average annual net growth of belowground biomass of trees (at least 1 inch d.b.h./d.r.c.), in dry short tons, on forest land
Denominator attribute number and description	127 Area change of forest land, in acres, on remeasured conditions where both measurements are forest
Forest land definition	FIADEF
Inventories	Show all available inventories
Press continue	
State/EVAL_GRP(s)	New Jersey 342022 (current inventory 2018-2022)
Press continue	
Page variable	None
Page temporal basis:	Current
Row variable	Forest type group (based on values from the Current inventory)
Row temporal basis:	Current
Column variable	Ownership group - Major (based on values from the Current inventory)
Column temporal basis:	Current
Output format	Download normalized estimates in CSV

The carbon density values are summarized in Table 13. These are used to derive emission parameters for the Anderson classes used in the activity data as described in the NJ NWL Calculator Manual (Section: Data collection, processing, and cleaning/Third party datasets 5).

Table 13. New Jersey forest type group carbon accumulation rates for estimating carbon stocks and fluxes in forest land remaining forest land (Reference: US Forest Service FIA, 2025)

Forest type group	Average annual net growth of AGB of trees			Average annual net growth of BGB of trees		
	Dry short ton biomass acre^{-1} year^{-1}	Dry short ton C acre^{-1} year^{-1}	Tonne C acre^{-1} year^{-1}	Dry short ton biomass acre^{-1} year^{-1}	Dry short ton C acre^{-1} year^{-1}	Tonne C acre^{-1} year^{-1}
	A#	B=A*0.5	C=B*0.907	D#	E=A*0.5	F=B*0.907
White/Red/Jack pine group	2.19 ± 1.7	1.096	0.988	0.49 ± 0.4	0.246	0.221
Loblolly/shortleaf pine group	1.24 ± 0.2	0.620	0.559	0.22 ± 0	0.108	0.097
Other eastern softwoods group	0.56 ± 0.1	0.282	0.254	0.08 ± 0.1	0.039	0.035

Forest type group	Average annual net growth of AGB of trees			Average annual net growth of BGB of trees		
	Dry short ton biomass $acre^{-1}$ $year^{-1}$	Dry short ton C $acre^{-1}$ $year^{-1}$	Tonne C $acre^{-1}$ $year^{-1}$	Dry short ton biomass $acre^{-1}$ $year^{-1}$	Dry short ton C $acre^{-1}$ $year^{-1}$	Tonne C $acre^{-1}$ $year^{-1}$
	A#	B=A*0.5	C=B*0.907	D#	E=A*0.5	F=B*0.907
Oak/pine group	0.87 ± 0.4	0.433	0.390	0.15 ± 0.1	0.077	0.069
Oak/hickory group	0.86 ± 0.3	0.428	0.386	0.14 ± 0.1	0.068	0.061
Oak/gum/cypress group	0.61 ± 0.3	0.304	0.274	0.09 ± 0.1	0.043	0.039
Elm/ash/cottonwood group	-0.17 ± 1	-0.083	-0.074	-0.08 ± 0.2	-0.038	-0.034
Maple/beech/birch group	-0.25 ± 1.1	-0.126	-0.113	-0.11 ± 0.2	-0.057	-0.051
Aspen/birch group	0.91 ± 0.1	0.456	0.411	0.1 ± 0	0.050	0.045
Other hardwoods group	1.39 ± 0.9	0.696	0.627	0.24 ± 0.2	0.121	0.109
Nonstocked	-3.51 ± 2.9	-1.756	-1.582	-0.69 ± 0.6	-0.347	-0.312

Column A, D values from FIA, all others derived as shown
AGB = aboveground biomass
BGB = belowground biomass
± value represents the 95% confidence interval

Mapping parameters from forest type group to Anderson classifications

The parameters derived from FIA data for each forest type group need to be mapped to Anderson classes used by the NJ LULC dataset, to estimate the mean Carbon density in each class. This is done in GIS by overlaying a forest type group map (shown in Figure 5A) with the NJ LULC forest classes (Figure 5B). This step is described in the NJ NWL Calculator Manual (Section: Data collection, processing, and cleaning/Third party datasets). Collaboration with BGIS team on this is highly recommended.

An average carbon density and accumulation rate is calculated for each Anderson sub-class by overlaying the map of forest type groups and associated carbon parameters and calculated a weighted average of carbon density and accumulation rates for each Anderson sub-class.

Parameters have been calculated based on data from the most recent FIA forest inventory (2022) at the time of writing and applied the most recent LULC dataset (2020) to derive emission parameters and estimate C stocks and C fluxes for the entire time series 1990-2024. The resulting carbon density and accumulation parameters are summarized in Table 14. Updated values should be re-derived and entered for future years into the New Jersey Forest calculator based on the new LULC dataset most recent FIA forest inventory data.

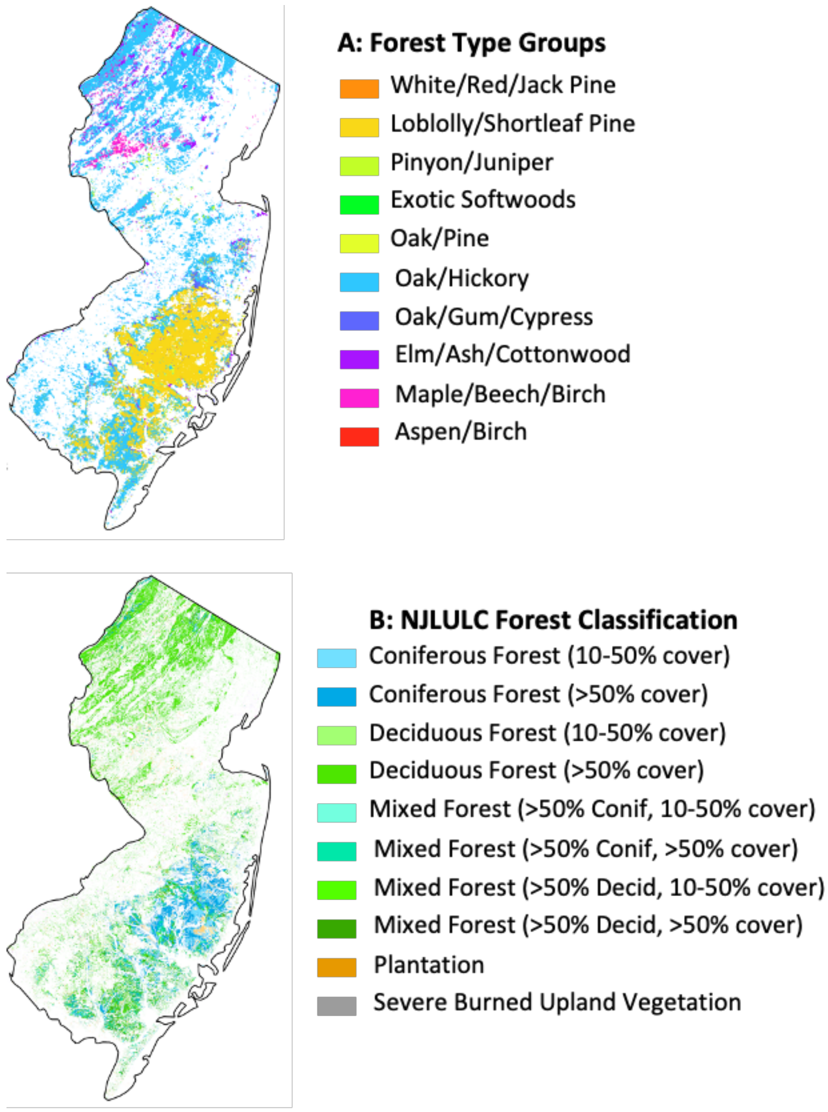

Figure 5. A – Distribution of forest type groups in New Jersey, B – Distribution of NJLULC forest classes in New Jersey

Table 14. Derived carbon densities and accumulation rates for estimating carbon stocks and fluxes in forest land remaining forest land for forest land NJ LULC sub-classes except plantation and severe burned upland vegetation

Forest sub-class (Anderson)	**Carbon density (tonne C acre^{-1})**					**Carbon accumulation (tonne C acre^{-1} year^{-1})**	
	AGB	BGB	DW	LI	SOC*	AGB	BGB
Coniferous forest, >50% crown closure	29.5	5.1	6.6	7.1	49.3	0.45	0.07
Coniferous forest, 10-50% crown closure	26.9	4.6	5.9	7.2	48	0.05	-0.01
Deciduous forest, >50% crown closure	35.1	6.1	8	6.8	52.2	0.35	0.05
Deciduous forest, 10-50% crown closure	35.1	6.1	8.1	6.8	52.6	0.27	0.03
Mixed forest, >50% coniferous with >50% crown closure	31.9	5.5	7.1	7	50.4	0.39	0.06
Mixed forest, >50% coniferous with 10-50% crown closure	32.2	5.6	7.3	6.9	50.7	0.42	0.07
Mixed forest, >50% deciduous with >50% crown closure	33.3	5.8	7.5	6.9	51.2	0.45	0.07
Mixed forest, >50% deciduous with 10-50% crown closure	33.1	5.8	7.5	6.9	51.4	-0.07	-0.03
*SOC provided for information only, not used in the calculator.							

For carbon density and accumulation parameters for plantation, IPCC default parameters are used as shown in Table 15. Aboveground biomass density and accumulation rates are provided. Default root-to-shoot (R) ratios are also provided and utilized to determine belowground biomass density and accumulation. Parameters for other C pools (DW, LI) are not available at this time, therefore 0 is used in the calculations.

Table 15. Plantation carbon densities and accumulation rates for estimating carbon stocks and fluxes in forest land remaining forest land (Reference: 2019 IPCC Refinement to the 2006 IPCC Guidelines)

AGB biomass (tonne dry matter hectare^{-1})	R ratio	BGB biomass (tonne dry matter hectare^{-1})	AGB biomass growth (tonne dry matter hectare^{-1} year^{-1})	R ratio	BGB biomass growth AGB*R (tonne dry matter hectare^{-1} year^{-1})
80.94 (68.21)	0.237±90%	19.18	2.9 (0.1)	0.237±90%	0.687
To convert biomass dry matter to biomass carbon, it is multiplied by 0.5					
AGB C Density (tonne C hectare^{-1})	BGB C Density (tonne C hectare^{-1})		AGB C accumulation (tonne C hectare^{-1} year^{-1})	BGB C accumulation (tonne C hectare^{-1} year^{-1})	
40.47	9.59		1.45	0.344	
To convert to units of tonne C acre^{-1} year^{-1}, values are divided by 2.47					
AGB C Density (tonne C acre^{-1})	BGB C Density (tonne C acre^{-1})		AGB C accumulatio (tonne C acre^{-1} year^{-1})	BGB C accumulation (tonne C acre^{-1} year^{-1})	
16.38	3.88		0.59	0.14	
AGB biomass for: Temperate, Continental, N. America, Pinus sp., Age > 20 years (Vol 4, Chap 4, Table 4.8) AGB net biomass growth for: Temperate, Continental, N.and S.America, Secondary > 20 years (Vol 4, Chap 4, Table 4.10) R ratio for: Temperate, Continental, N.and S.America, Planted (conifer), AGB <125 (Vol 4, Chap 4, Table 4.4) ± designates 95% confidence interval uncertainty range; values in () indicate standard deviation of the mean estimate.					

For severe burned upland vegetation, AGB carbon density was derived using the Forest Vegetation Simulator (FVS) and carbon accumulation parameters were taken from IPCC defaults for naturally growing forest (Table 16 and Table 17, respectively). Due to the absence of FIA forest inventory data representative of Forest Land classified as "Severely Burned Upland Vegetation" in the New Jersey, an area that is classified as severely burned in 2020 was identified within Wharton State Forest where high-resolution forest inventory data are available through the New Jersey Forest Service. The corresponding forest inventory data from this site were input into the Forest Vegetation Simulator (FVS), and a wildfire scenario was modeled to approximate the 2015 fire event that led to the current classification. Simulated carbon stocks were then estimated on a per-acre basis to represent post-fire conditions. These values are intended as modeled approximations of potential carbon outcomes and are not direct measurements. Additional details on the carbon calculations can be found in Section 2.6 of the Fire and Fuels Extension to the Forest Vegetation Simulator (USDA Forest Service). Parameters for the litter C pool are not available at this time, therefore 0 is used in the calculations.

Table 16. Severe burned upland vegetation carbon densities for estimating carbon stocks and fluxes in forest land remaining forest land derived using Forest Vegetation Simulator (Reference: derived and provided by NJ Forest Service)

AGB C Density (US ton acre^{-1})	BGB C Density (US ton C acre^{-1})	Standing DW C Density (US ton C acre^{-1})
11± 11%	3 ± 11%	9 ± 11%
To convert biomass dry matter to biomass carbon, it is multiplied by 0.5		
AGB C Density (tonne C acre^{-1})	**BGB C Density (tonne C acre^{-1})**	**Standing DW C Density (tonne C acre^{-1})**
9.98	2.72	8.16
± 95% confidence interval sampling and measurement uncertainty		

Table 17. Severe burned upland vegetation carbon accumulation rates for estimating carbon stocks and fluxes in forest land remaining forest land (Reference: 2019 Refinement to the 2006 IPCC Guidelines)

AGB biomass growth (tonne dry matter hectare^{-1} year^{-1})	R ratio	BGB biomass growth AGB*R (tonne dry matter hectare^{-1} year^{-1})
1.96 (0.04 SD)	0.481±90%	0.943
To convert biomass dry matter to biomass carbon, it is multiplied by 0.5		
AGB C accumulation (tonne C hectare^{-1} year^{-1})	**BGB C accumulation (tonne C hectare^{-1} year^{-1})**	
0.98	0.471	
To convert to units of tonne C acre^{-1} year^{-1}, values are divided by 2.47		
AGB C accumulation (tonne C acre^{-1} year^{-1})	**BGB C accumulation (tonne C acre^{-1} year^{-1})**	
0.397	0.191	
AGB net biomass growth for: Temperate, Continental, N.and S.America, Secondary < 20 years (Vol 4, Chap 4, Table 4.9) R ratio for: Temperate, Continental, N.and S.America, Natural (Other broadleaf), AGB <125 (Vol 4, Chap 4, Table 4.4) ± designates 95% confidence interval uncertainty range; values in () indicate standard deviation of the mean estimate		

Emission parameters presented in Table 14, Table 15, Table 16, and Table 17 should be entered in the NJ NWL Forest Land Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission Factors - 9).

Soil Carbon on Mineral Soils

It is assumed that SOC stock in mineral soils (all but histosols taxonomic order) remains unchanged, because management remained unchanged. Therefore, SOC fluxes on mineral soils in forest land remaining forest land are 0.

Land Converted to Forest Land

Biomass Carbon density and accumulation rates

The accumulation of carbon in biomass occurs as trees grow. The accumulation rate should be taken into account when estimating carbon stock increase in land converted to forest land categories as young trees grow faster and thus sequester more carbon per ha per year than mature trees. For plantation and severe upland burned vegetation classes, carbon accumulation rates were estimated using IPCC defaults (Table 18), for plantations and natural forests, respectively. For remaining land classes, FIA data was analyzed (Hoover and Smith, 2023) to derive aboveground live tree carbon density and carbon accumulation rates by stand age, by region, and by state where sufficient data were available. Regional estimates for the Northeast region were used since there were too few samples to estimate New Jersey specific parameters. Stand age 0-20 years was used as representative value for land converted to forest. Values for softwood forest were applied to coniferous forest classes, values for hardwood forests were applied to deciduous forest classes. For mixed forest classes, average value was used. IPCC default R ratios were used to estimate belowground biomass values (Table 18). Emission parameters presented in Table 18 should be entered in the NJ NWL Forest Land Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission Factors - 10).

Table 18. Carbon accumulation rates for estimating carbon stocks and fluxes in land converted to forest land (Reference: 2019 Refinement to the 2006 IPCC Guidelines, Hoover and Smith, 2003)

Forest sub-class (Anderson)	AGB biomass growth (tonne dry matter hectare^{-1} year^{-1})	R ratio	BGB biomass growth AGB*R (tonne dry matter hectare^{-1} year^{-1})
Plantation	4.1 (0.2 SD)	0.237±90%	0.972
Severe upland burned vegetation	1.96 (0.04 SD)	0.481±90%	0.943

To convert biomass dry matter to biomass carbon, it is multiplied by 0.5

Forest sub-class (Anderson)	AGB C accumulation (tonne C hectare^{-1} year^{-1})	BGB C accumulation (tonne C hectare^{-1} year^{-1})
Plantation	2.05	0.486
Severe upland burned vegetation	0.98	0.471
All coniferous classes	1.78	0.86
All deciduous classes	1.29	0.62
All mixed classes	1.47	0.82

To convert to units of tonne C acre^{-1} year^{-1}, values are divided by 2.47

Forest sub-class (Anderson)	AGB C accumulation (tonne C acre^{-1} year^{-1})	BGB C accumulation (tonne C acre^{-1} year^{-1})	Total biomass C accumulation (tonne C acre^{-1} year^{-1})
Plantation	0.83	0.197	1.027
Severe upland burned vegetation	0.397	0.191	0.588
All coniferous classes	0.72	0.35	1.07
All deciduous classes	0.52	0.25	0.77
All mixed classes	0.59	0.33	0.92

Plantations sub-class
AGB net biomass growth for: Temperate, Continental, N.and S.America, Secondary < 20 years (Vol 4, Chap 4, Table 4.10)
R ratio for: Temperate, Continental, N.and S.America, Planted (conifer), AGB <125 (Vol 4, Chap 4, Table 4.4)

Severe upland burned vegetation sub-class
AGB net biomass growth for: Temperate, Continental, N.and S.America, Secondary < 20 years (Vol 4, Chap 4, Table 4.9)
R ratio for: Temperate, Continental, N.and S.America, Natural (Other broadleaf), AGB <125 (Vol 4, Chap 4, Table 4.4)

Coniferous, deciduous, and mixed forest sub-classes
Aboveground live tree carbon accumulation rates for Northeast region, stand age 0-20 years was used. For coniferous and deciduous forests, values for softwood forests and hardwood forests groups, were used, respectively (Table S2). For mixed forests, the average rate was used (Table 2) (Hoover and Smith, 2023); R ratio for: Temperate, Continental, N.and S.America, Natural (Other broadleaf), AGB <125 (Vol 4, Chap 4, Table 4.4)

± designates 95% confidence interval uncertainty range; values in () indicate standard deviation of the mean estimate.

When land transitions from a category with existing biomass, it is assumed that all biomass is lost in the year of transition for croplands (removal of biomass) and that all biomass remains for grasslands, wetlands, and settlements (natural regeneration). The pre-transition C density for different land categories is provided in Table 19. Emission parameters presented in Table 19 should be entered in the NJ NWL Forest Land Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission Factors - 10).

Table 19. Carbon density parameters for Land Converted to Forest Lands. References provided in each land category section

Converted from	Pre-transition C density (tonne C $acre^{-1}$)	Converted to	Post-transition C accumulation (tonne C $acre^{-1}$ $year^{-1}$)
Cropland	Orchards - 2.58 Berries - 4.64 Annual crops – 1.9 Forage crops/pasture – 2.73	Forest	All forest classes except plantations - AGB: 0.397/BGB: 0.197 Plantations – AGB: 0.83/BGB: 0.191
Grassland	AGB: 0.714 BGB: 0.079		
Wetlands	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25 Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47 Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47 Estuarine Emergent Wetland – AGB:1.25/BGB:2.65		
Settlement	Open space – AGB: 11.8/BGB: 2.0 Low intensity development – AGB: 27.1/BGB: 4.4 Medium intensity development – AGB: 20.9/BGB: 3.7 High intensity development – AGB: 30.8/BGB: 4.2		
Other Land	0		

All parameters should be entered in the Forest Parameters tab in the New Jersey Forest calculator according to instructions in the NJ NWL Calculator Manual.

Soil Carbon on mineral soils

Fluxes in SOC in mineral soils (all but histosols taxonomic order) are expected to occur when land is converted. For mineral soils, IPCC default assumption is that it takes 20 years to reach a new equilibrium from the time management changed. However, since currently New Jersey doesn't track land transitions over 20 years, it is assumed that change in mineral soil carbon occurs in the year of transition. A combination of Tier 1 and 2 parameters will be used to estimate soil organic carbon fluxes listed in Table 20. Emission parameters presented in Table 20 should be entered in the NJ NWL Forest Land Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission Estimates - 13).

Table 20. Soil carbon stock change factors for Land Converted to Forest Land (Reference: 2019 Refinement to IPCC Guidelines and 2013 Wetland Supplement to IPCC Guidelines)

Converted from	Pre-transition stock change factors			Converted to	Post-transition stock change factors		
	F_{LU}	F_{MG}	F_{I}		F_{LU}	F_{MG}	F_{I}
Cropland – long term cultivated [a]	0.69	1	1	Forest	1	1	1
Cropland – set aside [a]	0.82	1	1		1	1	1
Cropland – perennial/tree crop [a]	0.72	1	1		1	1	1
Cropland – pastureland [a]	1	1	1		1	1	1
Grassland [b]	1	1	1		1	1	1
Wetlands – inland on mineral soils [c]	1	1	1		0.71	1	1
Settlements [d]	0.69	1	1		1	1	1
Other land [e]	NE	NE	NE		NE	NE	NE

[a] For Cropland converted to Forest, same proportions as cropland remaining cropland are assumed, with long term cultivated = annual crops and other crops, set aside = forage crops, perennial/tree crop = orchard and berries, pastureland is the proportion of cropland that's permanent pasture and is treated as nominally managed grassland. It is assumed that conventional tillage and medium input cropping is representative of for all cropland converted
[b] For grassland converted to forest land, nominally managed grassland is assumed, SOC is assumed to equal to SOC_{REF}
[c] SOC flux estimated for inland wetlands on mineral soils converted to forest, F_{LU} is assumed to be = to cropland with long-term cultivation
[d] For settlements, the same value as cultivated cropland is assumed
[e] For other land converted to forest land, SOC flux is not estimated

Emissions from Drained Organic Soils (all forest land)

Forest land occurring on organic soils (histosols taxonomic order) are assumed to be not drained, therefore CO_2, N_2O, and CH_4 are not estimated. This is a conservative assumption as there is knowledge of areas that have been drained. Parameters are provided for future use when proportion of organic soils that are drained have been estimated. The same parameters are used to estimate emissions for forest land remaining forest land and land converted to forest land. The emission factors are provided in Table 21. Emission parameters presented in Table 21 should be entered in the NJ Forest Land Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Land Area – 8, Note emission factors for drained organic soil emissions are entered in the same sheet as the land area). The proportion (%) of the organic soils will also need to be entered in the NJ Forest Land Calculator when data is available.

Table 21. Emission factors for drained organic soils on Forest Land.

Parameter	Gas	Value	Unit	Converted value	Unit
EF, direct emissions	**CO_2**	2.6 (2.0 – 3.3)	tonne CO_2-C hectare^{-1} year^{-1}	1.05	tonne CO_2-C acre^{-1} year^{-1}
EF, indirect emissions	**CO_2**	0.31 (0.19 – 0.46)	tonne C hectare^{-1} year^{-1}	0.125	tonne C acre^{-1} year^{-1}
EF, direct emissions	**N_2O**	2.8 (-0.57 – 6.1)	kg N_2O-N hectare^{-1} year^{-1}	0.00113312	tonne N_2O-N acre^{-1} year^{-1}
EF, land	**CH_4**	2.5 (-0.60 – 5.7)	kg CH_4 hectare^{-1} year^{-1}	0.00101171	tonne CH_4 acre^{-1} year^{-1}
EF, ditch	**CH_4**	217 (41-393)	kg CH_4 hectare^{-1} year^{-1}	0.0878168	tonne CH_4 acre^{-1} year^{-1}
Frac_ditch	**CH_4**	0.025	unitless	0.025	Unitless
Values in () represent the 95% confidence interval. Reference: IPCC 2013 Wetland Supplement, Chapter 2					

Harvested wood products (for information only)

The NGHGI includes changes in C stocks for harvested wood products (HWP) in the Forest Land Category. The NGHGI uses the WOODCARBII model, which implements the production approach outlined in the IPCC 2006 Guidelines. The harvested wood pool contains two components:

1. Carbon stored in products held in end use (e.g., construction materials, furniture)
2. Materials managed in solid waste disposal services, and solid waste disposal sites (SWDS)

Application of this model in the state context is not applicable as estimating fluxes requires the selection of assessment boundaries, inclusion/exclusion of materials harvested outside of the inventory area or exported to areas outside of the inventory delineated area (e.g., New Jersey geographical boundary). As such, the NGHGI methodology is not applicable, and US EPA does not provide state disaggregated estimates of HWP C fluxes.

To estimate changes in C stocks in the SWSD pool (i.e., wood and paper material that is landfilled in state), IPCC Waste FOD model was used (see Settlements section for more details). These estimates are provided for information only due to ability to only account for C fluxes in SWDS C pool only, inconsistent activity data across the time series, and high uncertainty.[9]

[9] Input data used in the IPCC FOD model is the same as used to estimate Waste emissions in the SIT tool, considering only tonnage of waste landfilled in state, with tonnage of wood and paper waste estimated based on national average waste distribution.

Calculations

Carbon fluxes and non-CO_2 emissions are calculated automatically by the New Jersey Forest calculator when activity data and emission parameters are entered by the user (see NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission estimates). Net GHG emissions and removals are calculated annually for each land category using the following approaches, consistent with the 2006 IPCC Guidelines and assumptions:

- Stock-Difference Approach: Used for carbon pools, where change is estimated as the difference in stocks at two points in time - changes in biomass C and SOC when land transitions from other
- For estimating biomass C fluxes when land is converted, it is assumed that natural regeneration occurs for grassland to forest land, settlements to forest land, and wetland to forest land so that biomass remains; is assumed that biomass is cleared when cropland is converted to forest land so that biomass is lost
- When cropland is converted to forest land, is assumed that the cropland with the same proportional distribution of crop systems as in cropland category is converted and it is all under conventional tillage and has medium levels of inputs
- For estimating SOC fluxes when land is converted, it is assumed that all SOC stock changes in the year of transition (rather than in 20 years as IPCC Guidelines states) because data currently does not track 20-year transitions and likely the change is long term.
- Gain-Loss Approach: Used for carbon pools, where change is estimated as the net of gains and losses over the period – changes in biomass C for land remaining in forest land
- CO_2 and non-CO_2 (methane and nitrous oxide) emissions from drained soils are estimated by multiplying Forest land area by emission factor for all forest land

The C fluxes and non-CO_2 emissions are estimated by the New Jersey Forest Calculator according to the following formulas. Note that emission factors in section above are provided in units in which they were derived and published. Activity data are converted by the calculator to the proper units, as needed.

Forest land remaining forest land

Biomass Carbon Flux

Biomass C fluxes are changes in C stocks for aboveground and belowground biomass C pools due to gains and/or losses. Annual biomass C flux is calculated for each forest class and summed together to estimate total annual flux.

Equation 2. FRF Biomass Carbon Flux

$$Biomass\ Carbon\ Flux\ (tonne\ C\ year^{-1}) = Forest\ remaining\ forest\ area\ (acre) \times C\ accumulation\ rate$$

Convert C to CO_2 (44/12) and multiply by -1 to indicate removals

Carbon Stock

Carbon stock for each year is the sum of carbon in all forest C pools in a given year. C stock is calculated for each forest class and summed together to estimate total C stock.

Equation 3. FRF Biomass Carbon Stock

$$Carbon\ Stock\ (tonne\ C) = Forest\ remaining\ forest\ area\ (acre) \times (AGB + BGB + DW + LI\ C\ density)$$

Land converted to forest land

For conversion from cropland, all pre-transition biomass is assumed to be removed and biomass C accumulation in forest begins the year of transition.

For conversion from grasslands, wetlands, and settlements, all pre-transition biomass is assumed to remain and biomass C accumulation in forest begins the year of transition as these types of lands are assumed to undergo conversion to forest through natural regeneration.

Biomass Carbon Stock Change (conversion)

C stock changes are calculated for each class converted to forest and summed together to estimate total C stock change due to conversion.

Equation 4. LCF Biomass Carbon Stock Change from conversion from cropland

$$Biomass\ Carbon\ Stock\ Change\ (tonne\ C) = Land\ converted\ to\ forest\ area\ (acre) \times Biomass\ Carbon\ Density_{pre-transition}$$

Equation 5. LCF Biomass Carbon Stock Change from conversion from grasslands, wetlands, and settlements

$$Biomass\ Carbon\ Stock\ Change\ (tonne\ C) = (-1) \times Land\ converted\ to\ forest\ area\ (acre) \times Biomass\ Carbon\ Density_{pre-transition}$$

Biomass Carbon Gain

C stock gains are calculated for each forest type and summed together to estimate total C stock change due to growth of new forest.

Equation 6. LCF Biomass Carbon gain from forest growth

$$Biomass\ Carbon\ Gain\ (tonne\ C) = (-1) \times Land\ converted\ to\ forest\ area\ (acre) \times Biomass\ C\ accumulation\ rate$$

The total biomass carbon flux for land converted to forest is the sum of stock changes due to conversion and gains for new forest. C is converted to CO_2 by multiplying by (44/12).

Soil organic carbon flux

SOC flux in mineral soil is calculated using Equation 1 (without dividing by 20)

NOTE: SOC flux is estimated for newly converted land each year, which is linearly interpolated between datasets. Therefore, SOC flux is equal for each year within a period between datasets.

Drained organic soil emissions

Annual emissions are estimated for each gas for each year in the time series, converted to CO_2e and totaled.

CO_2 emissions from drained soils

Equation 7. Drained Organic Soils on-site CO2 emissions

a. $$Annual\ on-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ forest\ land\ area\ (acre) \times\ EF$$

Equation 8. Drained Organic Soils off-site CO2 emissions

b. $$Annual\ off-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ forest\ land\ area\ (acre) \times\ EF$$

NOTE: convert CO_2-C to CO_2 (44/12)

N_2O emissions from drained soils

Equation 9. Drained Organic Soils N2O emissions

$$N_2O\ emissions\ from\ drained\ soils (tonne\ N_2O-N\ year^{-1}) = [Drained\ forest\ land\ area\ (acres) \times\ EF]$$

NOTE: convert N_2O-N to N_2O (44/28)

CH_4 emissions from drained soils

Equation 10. Drained Organic Soils CH4 emissions

$$CH_4\ emissions\ from\ drained\ soils\ (tonne\ CH_4\ year^{-1}) = \left\{ Drained\ forest\ land\ area\ (acres)\ \times \begin{bmatrix} ((1-Frac_{ditch}) \times EF_{land}) \\ + \\ ((Frac_{ditch}) \times EF_{ditch}) \end{bmatrix} \right\} \div$$

Emissions and removals are provided for forest land remaining forest land and land converted to forest land for each Anderson sub-class, and by carbon pool as applicable. The summary tab in the Forest Calculator provides total emission by main categories.

Uncertainty

Underlying uncertainties in the estimates of biomass carbon stock changes and non-CO_2 emissions in Forest Lands include uncertainties associated with values for biomass carbon stocks and emissions factors for drained organic soils. For biomass carbon stock parameters, error/SD is provided for FIA measurements, however, uncertainty is potentially propagated and increased when FIA forest type group C densities are mapped to Anderson sub-categories used in the inventory. Uncertainty associated with default parameters utilized in the calculations (soil carbon stock change factors for land converted to forests, biomass C accumulations rates) is propagated.

Furthermore, assumptions on temporal dynamics that underlie the methodological approaches applied lead to uncertainty. When land is converted from other land uses to forest, soil carbon stocks may take 20 years or more to reach equilibrium. Currently, we assume that the change occurs in the year of transition because 20-year transitions are not tracked. This results in C flux appearing in 1 year rather than spread out over a 20-year period which may appear as an overestimation. If the land conversion is maintained over the long term, the C flux trend, averaged over time, will balance out. Furthermore, a 20-year transition period is used to differentiate between biomass accumulation rates for new and mature forests. Because the New Jersey land use land cover dataset is updated every 3-5 years, currently, forests are kept in the transitioned category for a shorter period of time leading to potential underestimation of C removal by younger forests.

Also, there are uncertainties linked to the land use activity data from the NJ LULC dataset due to interpretation of remote sensing data – NJ LULC sub-categories such as plantations and severe burned upland vegetation lacks information regarding associated vegetation, management, and transitions.

Because emissions from organic soils are not estimated, the overall emissions are underestimated as some drainage is expected to occur despite lacking systematic data.

Future improvements

Data gaps

Because the New Jersey land use land cover dataset is updated every 3-5 years, assumptions need to be made regarding the land area in each land category for years between two consecutive data sets. Currently, the area remains fixed to the last year of the available dataset. To fill gaps in data in a more realistic way, for years before an updated dataset is available, the inventory could use the National Land Cover Dataset (NLCD), available annually from US Geological Survey data as a proxy for state level data. Because the NLCD and NJ LULC use different methodologies and classifications, the values for forest land area are not equal. However, the annual changes in the NLCD land distribution can be used to determine representative land use change trends. Such trends can be applied to existing data NJ LULC data to fill in the gaps before the new NJ LULC dataset becomes available. When the updated NJ LULC dataset is published, data can be entered into the calculator under the activity data tab. This will result in a recalculation of emissions and removals for the years where data gaps were filled previously by proxy.

Activity data

Currently, it is assumed that plantation forest is a pine plantation and default emission parameters are used to estimate C fluxes. Obtaining additional activity data to differentiate plantation species could help improve accuracy in estimations of C density.

Classification of organic soils is based on soil taxonomy data from SSURGO with all histosols assigned to organic soils and assumed to be undrained. However, there is evidence that drainage occurs in forest areas. Assessment of proportion of area of drained organic soils will help improve the accuracy of the estimates.

Emission parameters

Currently, an IPCC default value is used to estimate carbon gain in forests affected by fire and plantations. Likewise, IPCC default parameters are applied for C stocks for plantations. C stock values for forests in the severe burned upland vegetation sub-classes were derived using the Forest Vegetation Simulator. It is recommended that the New Jersey inventory compilation team collaborate with the New Jersey Forest Service to derive emission parameters based on FIA data from New Jersey plots or collect additional data to derive needed parameters. For improving parameters for forests affected by fires, data collection is ongoing for a new forest inventory of certain areas in Wharton State Forest that have had wildfires in the past 5 years. This will enable comparisons pre-wildfire plot data to post-wildfire plot data, and derivation of C density parameters for the forest lands impacted by fire that can be used in the future.

Furthermore, during the preparation of this version of the SOP (v1.1), US Forest Service updated allometric equations used in estimating reported FIA data parameters and associated carbon density and accumulation rate values used in the inventory estimates. The update resulted in a slight increase in estimated values. It is strongly recommended that the inventory team update the carbon density and accumulation rate values in Table 11 and Table 13, and update associated values in Table 14 that are used in the calculations of the inventory emissions and removals for the publication of the inventory update in 2026 to avoid future recalculations and reporting variation in emission and removal levels that are due to methodological changes rather than real changes in forest carbon dynamics.

CROPLAND

Cropland Definitions

This category includes areas that are used for crop production, annual and perennial, as well as non-cultivated land such as continuous forage crops, and fallow lands that are temporarily set aside. The methodology considers GHG emissions and removals due to changes in biomass, dead organic matter, and soil C stocks in the cropland category. In accordance with IPCC 2006 Guidelines, biomass and dead organic C stocks in agricultural lands are considered ephemeral except for perennial crops/other agroforestry systems or wooded/shrub vegetation, in cropland and grasslands, respectively. The following categories are accounted for in the Cropland category:

- Carbon fluxes in Cropland remaining Cropland (by carbon pool)
- Carbon fluxes in Land Converted to Forest Land (by carbon pool)
- Emissions from drained organic soils (CO_2, CH_4, and N_2O)

The NJ LULC dataset currently does not differentiate between cropland and pasture. Land with perennial crops is reported as separate sub-class, however it also includes vineyards, nurseries, and other horticultural areas, which may have annual crops. Data from the US Agricultural Census are used as proxies to differentiate land into categories by vegetation and management systems to improve the accuracy of the GHG estimates. The data flows required for generation of emission and removal estimates in cropland are shown in Figure 6.

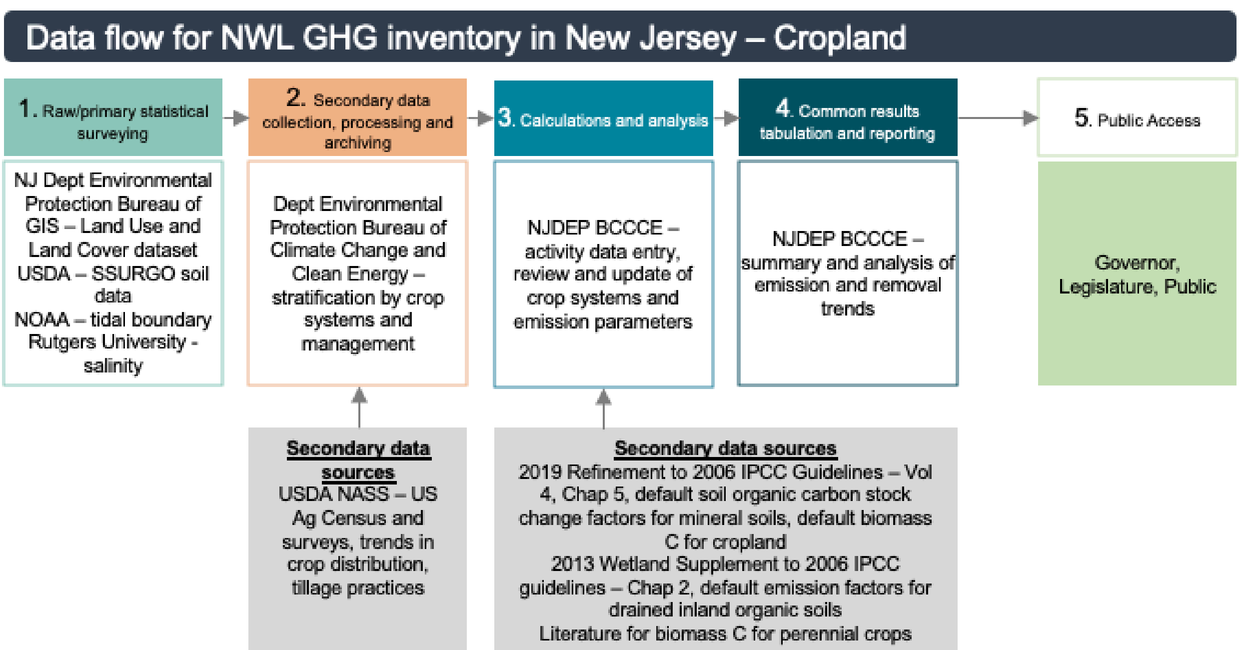

Figure 6. Data flow for NWL GHG inventory in New Jersey for the Cropland category

Activity Data

Stratification by soil type

All croplands are disaggregated by soil taxonomic order into mineral or organic soils. Soil organic carbon (SOC) fluxes occur due to changes in management and land conversion. For croplands on mineral soils, SOC fluxes are estimated using approach described in the cross-cutting section (see Equation 1) and detailed below. Furthermore, organic soils that have been drained emit CO_2, N_2O, and CH_4. Data on taxonomic order was taken from the USDA SSURGO dataset (retrieved May 2025). See cross-cutting section for the steps on data preparation and processing. Area of cropland occurring on mineral and organic (assumed to be drained) soils is entered as activity data following instructions in the NJ NWL Calculator Manual (Section: Cropland Calculator/Land Area).

Land area and cropping systems

The NJ LULC dataset currently lists 4 sub-classes under Agricultural Land type. In addition to lands used for crop cultivation and pasture, other agricultural lands and areas used for confined feeding operations are also classified as agriculture. For the purposes of the NWL inventory, these sub-classes are reassigned to other land categories because they do not have cropping/vegetation and land management activities representative of agricultural land. Therefore, as stated in Table 6, sub-classes included in Cropland category include:

- 2100: Cropland and pastureland
- 2200: Orchards/Vineyards/Nurseries/Horticultural areas

The process starts similar to other land categories - for each year when an updated LULC dataset is available, area for each of the categories is prepared according to the steps outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning) and disaggregated by remaining and converted to cropland. Data is entered according to sub-class and soil type (see Section Cropland Calculator/Land area 1A).

To further disaggregate land based on cropping system and management, US Agricultural Census for years 2002, 2007, 2012, 2017, and 2022 was used to determine proportion of land used for vegetable, forage, berry and fruit crops, and permanent pasture to align with land use categories for which default stock change parameters are available in the 2019 Refinement to the 2006 IPCC Guidelines. The years of the US Ag Census align well with NJ LULC data sets (2002, 2007, 2012, 2015, 2020). To disaggregate the NJ LULC sub-classes, relative proportions of specific types of crops were determined based on areas reported by the US Ag Census and associated proportions. Areas of woody perennial crops such as orchards and berries were subtracted from total cropland area to align best with NJ LULC sub-class of Cropland and pastureland. Direct comparisons were not possible due to differences in definitions and methodology. The data and associated proportions are shown in Table 22.

The sub-class Orchards/Vineyards/Nurseries/Horticultural areas contains agricultural areas, which are defined as being intensively managed for production of fruits, trees, ornamental plants, and vegetable seedlings. Wholesale greenhouses where plants are grown are also included in this category as are orchards, nurseries, blueberry farms, vineyards, sod and seed farms, and commercial greenhouses. Areas delineated include actively cultivated lands as well as land associated with the operations as, uncultivated lands, dirt roads, dikes, etc. To identify and disaggregate proportion of area with woody perennial vegetation and estimate biomass carbon storage, data from US Ag Census for orchards and berries was used within the Orchards/Vineyards/Nurseries/Horticultural areas sub-class. In New Jersey, main orchards crops are apples and peaches, and main berry crops are blueberries. The data and associated proportions are shown in Table 22.

For a complete time series, to disaggregate sub-class Cropland and Pastureland, average proportion was taken for annual row crops, annual vegetable crops, perennial crops, and permanent pasture as shown in Rows H, I, J, and K. For sub-class Orchards/Vineyards/Nurseries/Horticultural areas, the distribution varied between Ag Census years without an apparent trend, therefore, proportion of fruit tree and berry crops was held constant for the years prior to first and following last data points available, equaling 2002 values for years 1990-2001 and equaling 2022 data for years 2023-2024. Values between available data points were determined using linear extrapolation. The resulting variation is shown in Figure 7 and values for each year are tabulated in Table 23. Additional guidance on disaggregation of cropland data is provided in the NJ NWL Calculator Manual (Section: Data collection, preparation, and leaning/Third party datasets). The information on land disaggregregation is entered into the NJ Cropland Calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Land area 1A).

Table 22. US Agriculture Census data and subsequent data processing steps to enable disaggregation of NJ LULC agricultural land classes..

Crop type (acres)	Row	2002	2007	2012	2017	2022	Reference	Ave
Total cropland (acres)	A	547,668	488,697	456,751	463,019	449,717	US Ag Census[a]	
Vegetable crops (included in total cropland) (acres)	B	59,024	54,062	50,396	47,798	42,954	US Ag Census	
Forage crops (included in total cropland) (acres)	C	119,052	115,669	102,624	104,414	98,972	US Ag Census	
Berries (except strawberries) (included in total cropland) (acres)	D	10,948	13,009	13,590	13,396	14,907	US Ag Census	
Non-citrus fruit (all) (included in total cropland) (acres)	E	12,157	10,419	8,666	9,090	8,678	US Ag Census	
Permanent pasture and rangeland (acres)	F	41,579	54,007	64,304	63,995	60,180	US Ag Census	
Cropland used for annual crops (acres)	G = A – C - D - E	405,511	349,600	331,871	336,119	327,160	Calculation	
% Perennial herbaceous crops in cropland and pastureland	H = C / (G+C+F)	21.0%	22.3%	20.6%	20.7%	20.4%	Calculation	**21.0%**
% Permanent pastureland in cropland and pastureland	I = F / (G+C+F)	7.3%	10.4%	12.9%	12.7%	12.4%	Calculation	**11.1%**
% Annual vegetable crops in sub-class cropland and pastureland	J = B / (G+C+F)	10.4%	10.4%	10.1%	9.5%	8.8%	Calculation	**9.8%**
% Annual row crops in sub-class cropland and pastureland	K = 100% - H – I - J	61.2%	56.9%	56.4%	57.1%	58.4%	Calculation	**58.0%**
Area of Orchards/Vineyards/Nurseries/Horticultural areas (acres)	L	53,599	59,669	60,893	57,924	56,617	NJ LULC [b]	
% Berries (except strawberries) in sub-class Orchards/Vineyards/Nurseries/Horticultural areas	M = D/L	20%	22%	22%	23%	26%	Calculation	
% Non-citrus fruit in sub-class Orchards/Vineyards/Nurseries/Horticultural areas	N = E/L	23%	17%	14%	16%	15%	Calculation	
% other in sub-class Orchards/Vineyards/Nurseries/Horticultural areas	O = 100% - M - N	57%	61%	63%	61%	58%	Calculation	

[a] US Ag Census tables used: Table 8 – total cropland, permanent pasture, Table 31 – forage crops, Table 37 – fruits and nuts crops, Table 38 – berry crops.
[b] NJ LULC datasets are collected in years 2002, 2007, 2012, 2015, and 2020 – years 2015 and 2020 are assumed to be representative of Ag Census data in 2017 and 2022.

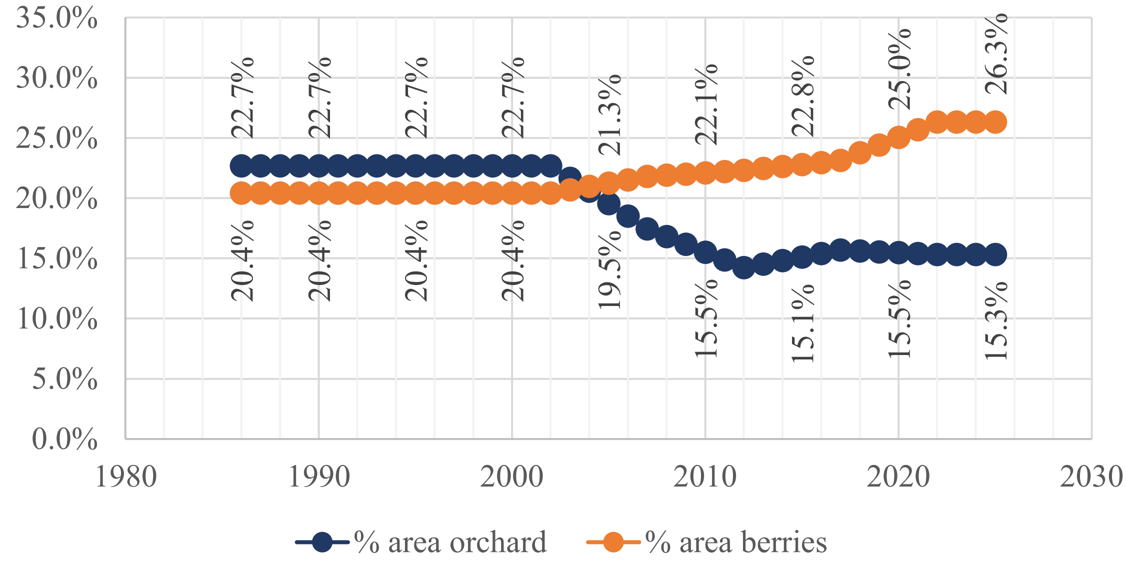

Figure 7. Estimated proportion of land used for cultivating orchards (blue) and berries (orange) in New Jersey between 1986 and 2025, out of land area in the Orchards/Vineyards/Nurseries/Horticultural sub-class.

Table 23. Estimated proportion of land used for cultivating orchards and berries in New Jersey between 1986 and 2025, out of land area in the Orchards/Vineyards/Nurseries/Horticultural sub-class.

Year	% area orchard	% area berries	Year	% area orchard	% area berries
1986	22.7%	20.4%	2006	18.5%	21.5%
1987	22.7%	20.4%	**2007**	**17.5%**	**21.8%**
1988	22.7%	20.4%	2008	16.8%	21.9%
1989	22.7%	20.4%	2009	16.2%	22.0%
1990	22.7%	20.4%	2010	15.5%	22.1%
1991	22.7%	20.4%	2011	14.9%	22.2%
1992	22.7%	20.4%	**2012**	**14.2%**	**22.3%**
1993	22.7%	20.4%	2013	14.5%	22.5%
1994	22.7%	20.4%	2014	14.8%	22.6%
1995	22.7%	20.4%	2015	15.1%	22.8%
1996	22.7%	20.4%	2016	15.4%	23.0%
1997	22.7%	20.4%	**2017**	**15.7%**	**23.1%**
1998	22.7%	20.4%	2018	15.6%	23.8%
1999	22.7%	20.4%	2019	15.5%	24.4%
2000	22.7%	20.4%	2020	15.5%	25.0%
2001	22.7%	20.4%	2021	15.4%	25.7%
2002	**22.7%**	**20.4%**	**2022**	**15.3%**	**26.3%**
2003	21.6%	20.7%	2023	15.3%	26.3%
2004	20.6%	21.0%	2024	15.3%	26.3%
2005	19.5%	21.3%	2025	15.3%	26.3%
Bold font represents years of Ag Census data.					

These cropland categories are aligned to the IPCC Guidelines categories for which default parameters are available as shown in Table 24.

Table 24. Crop systems land use categories

Crop system	Land use category	Description
Annual row crops Annual vegetable crops Other cropland [a]	Long term cultivated	Represents area that has been converted from native conditions and continuously managed for predominantly annual crops over 50 yrs. Land-use factor has been estimated under a baseline condition of full tillage and nominal ('medium") carbon input levels. Input and tillage factors are also applied to estimate carbon stock changes, which includes changes from full tillage and medium input.
Perennial herbaceous (forage) crops	Set aside	Represents temporary set aside of annually cropland (e.g., conservation reserves) or other idle cropland that has been revegetated with perennial grasses.
Perennial woody (orchards and berries) crops	Perennial/tree crop	Long-term perennial tree crops such as fruit and nut trees.
Permanent pasture	Nominally managed pasture (non – degraded)	Represents low or medium intensity grazing regimes, in addition to periodic cutting and removal of above-ground vegetation, without significant management improvements.

[a] Includes all other cropland in the Orchards/Vineyards/Nurseries/Horticultural areas sub-class

Cropland area for each of sub-classes is further disaggregated by soil type – mineral or organic. For cropland on mineral soils, for annual crops (assumed to be the proportions estimated in rows J and K in Table 22), the data is further disaggregated by management. Tillage intensity has been shown to have an impact on soil carbon removal rates (Ogle 2003). New Jersey currently doesn't collect this data, therefore the US Ag Census data from 2012, 2017, and 2022 were used to obtain a proportion of crops managed with conventional, conservation, or no-till practices. These proportions, applied to area of annual row crops in the state, were used to estimate area of cropland under different tillage regimes. The data for years 2012, 2017, and 2022 is used to derive a linear trend as shown in Table 25 and Figure 8 to generate values for the inventory time series. The proportion of no-till, reduced till, and conventional till areas for each year are tabulated in Table 26. For future years of the inventory time series until new data is available, the trend equation should be used to estimate relative distribution of tillage practices. For all other cropland, it is assumed that is it all under conventional tillage. For other crops, it is assumed that all perennial herbaceous and woody crops, and permanent pasture are under no-till regime. The information on management is entered into the NJ Cropland Calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Land area 1B).

When additional data on tillage trends is available (next US Agriculture Census is expected to be published in 2027), trend should be adjusted by fitting a new linear equation to the existing data points and distribution of land under different tillage regimes estimated and associated emissions recalculated for the entire time series.

Table 25. Trends in cropland management based on US Agriculture Census data.

Cropland practice (acres)		2012	2017	2022	Trend Equation
No till	A	88,180	104,499	114,503	
Reduced till	B	58,600	69,579	71,048	
Conventional till	C	126,479	95,406	80,675	
Total area [a]	D	273,259	269,484	266,226	
% No till	E = A/D	32.3%	38.8%	43%	% = 0.0107 (year) - 21.202
% Reduced till	F = B/D	21.4%	25.8%	26.7%	% = 0.0052 (year) - 10.444
% Conventional till	G = C/D	46.3%	35.4%	30.3%	% = -0.016 (year) + 32.645

[a] Note that the total area of cropland in row D is the area for which tillage data is reported in the US Ag Censes, it does not equal total area of cropland reported in the US Ag Census or New Jersey. Therefore, relative proportions and trends are utilized. US Ag Census Table 47 – land use practices.

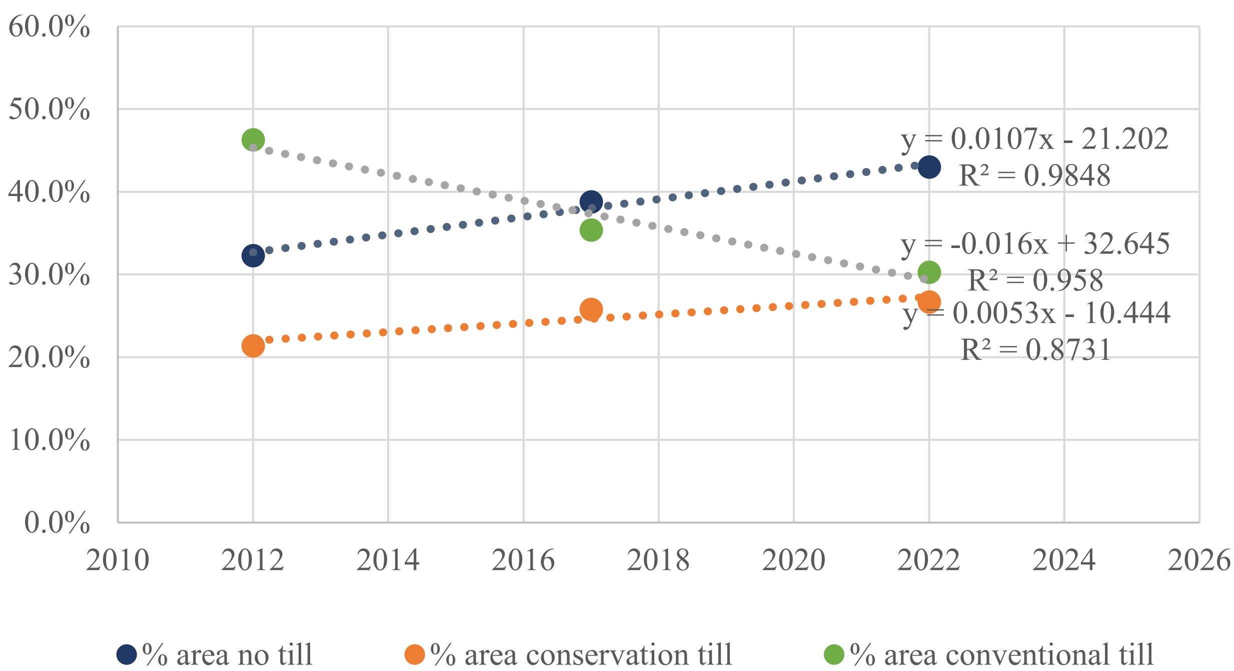

Figure 8. Linear fit to estimate trend in tillage practices in New Jersey based on data from 2012, 2017, and 2022 USDA Agriculture Census for no-till (blue), conservation till (orange), and conventional till (green).

Table 26. Proportion of cropland with annual crops under different tillage regimes in New Jersey based on linear trendline for 2012, 2017, and 2022 USDA Agricultural Census data.

Year	No till	Reduced till	Conventional till	Year	No till	Reduced till	Conventional till
1986	5%	8%	87%	2006	26%	19%	55%
1987	6%	9%	85%	2007	27%	19%	53%
1988	7%	9%	84%	2008	28%	20%	52%
1989	8%	10%	82%	2009	29%	20%	50%
1990	9%	10%	81%	2010	30%	21%	48%
1991	10%	11%	79%	2011	32%	21%	47%
1992	11%	11%	77%	**2012**	33%	22%	45%
1993	12%	12%	76%	2013	34%	22%	44%
1994	13%	12%	74%	2014	35%	23%	42%
1995	14%	13%	73%	2015	36%	24%	41%
1996	16%	13%	71%	2016	37%	24%	39%
1997	17%	14%	69%	**2017**	38%	25%	37%
1998	18%	15%	68%	2018	39%	25%	36%
1999	19%	15%	66%	2019	40%	26%	34%
2000	20%	16%	65%	2020	41%	26%	33%
2001	21%	16%	63%	2021	42%	27%	31%
2002	22%	17%	61%	**2022**	43%	27%	29%
2003	23%	17%	60%	2023	44%	28%	28%
2004	24%	18%	58%	2024	45%	28%	26%
2005	25%	18%	57%	2025	47%	29%	25%
Bold font represents years of Ag Census data.							

Soil Carbon stocks can also change with different levels of fertilizer or residue inputs (Ogle 2003). Cropping systems need to be further disaggregated categorically based on input to estimate associated carbon stocks and fluxes as low, medium, high, or high w/manure systems. The cropping systems currently discernable in the activity data will be characterized as shown in Table 27. The information on crop systems is entered into the NJ Cropland Calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Documentation 3).

Table 27. Cropland management categories

Crop system	Input Category	Description
Annual vegetable crops	Low-input cropping	Low residue return occurs when there is removal of residues (via collection or burning), frequent bare-fallowing, production of crops yielding low residues (e.g., vegetables), no mineral fertilization or N-fixing crops.
Other cropland	Low-input cropping	
Annual row crops	Medium-input cropping	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires mineral fertilization or N-fixing crop in rotation.
Perennial herbaceous (forage) crops	Medium-input cropping	
Perennial woody (orchards and berries) crops	Medium-input cropping	
Permanent pasture	Medium-input cropping	
NA	High-input cropping	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see row below).
NA	High-input cropping w/manure	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure.
NA indicates that data to capture such practice systematically are not currently available.		

For each year when an updated LULC dataset is available, cropland area for each of sub-classes is further disaggregated by cropland remaining cropland and land converted to cropland similar to other land categories. For land converted to cropland, the area and disaggregation by crop system is entered into the NJ Cropland Calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Land area 3-6).

NOTE: All data entered in the New Jersey NWL calculator must be in acres as the area units. Acres is also the unit from the source dataset. Therefore, no conversions are necessary.

Emission factors

Cropland remaining cropland

Biomass

Tier 1 biomass parameters for orchards and vineyards are provided in the IPCC 2019 Guidelines. Carbon density for mature blueberry plants is used to represent biomass C in berry plants in New Jersey (Table 28). Emission factors are entered in the NJ Cropland calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Emission factors).

Table 28. Carbon densities for estimating carbon stocks and fluxes in cropland remaining cropland and when land is converted

Crop type	Mean Biomass Carbon Density		Reference
Orchards (mean aboveground)	6.4 ± 25% tonne C ha^{-1}	2.58 tonne C $acre^{-1}$	2019 Refinement, Vol 4, Chap 5, Table 5.3
Berries (Mature blueberry plants)	11.47 (9.6 – 13.2) tonne C ha^{-1}	4.64 tonne C $acre^{-1}$	Denise Nemeth et al (2017)
Annual crops	4.7 ± 75% tonne C ha^{-1}	1.9 tonne C $acre^{-1}$	2019 Refinement, Vol 4, Chap 5, Table 5.9
Forage crops and permanent pasture*	13.5 ± 75% tonne d.m. ha^{-1}	2.73 tonne C $acre^{-1}$	2006 IPCC Guidelines, Vol 4, Chap 6, Table 6.4
* To convert from dry matter (d.m.) to carbon (C), multiply by 0.5			

Soil organic carbon in mineral soils

Soil organic carbon stocks change in mineral soils is calculated using stock change factors that depend on cropping system as outlined in Table 29.

Table 29. Carbon stock change factors based on evaluating effect of changing management from a conventionally tilled agricultural field with medium-input cropping, at 30cm depth after 20 years (Reference: 2019 Refinement to 2006 IPCC Guidelines)

Factor	Level	Crop type	Stock change factor (dimensionless)
F_{LU} Land use	Cultivated	Annual crops (both row and vegetable crops), other cropland	0.69±16%
	Set aside (perennial grasses or conservation reserve)	Forage crops	0.82±17%
	Perennial/Tree crop	Orchards, berries	0.72±22%
	Nominally managed pasture	Permanent pasture	1
F_{MG} Management regime (tillage)#	Conventional	Annual crops (proportion), other cropland	1
	Reduced till	Annual crops (proportion)	1.05±4%
	No-till	Annual crops (proportion), forage, orchard, berry crops	1.1±4%
F_{I} Inputs (Amendments and residue)	Low	Annual vegetable crops, other cropland	0.92±14%
	Medium	Annual row crops, forage, orchard, berry crops, permanent pasture	1
	High	NA	1.11±10%
	High with amendments	NA	1.44±13%
Values from Vol 4, Chap 5, Table 5.5, parameters for warm moist temperate climate zone # for nominally managed pasture/permanent pasture category, F_{MG} is 1 as for grassland			

Land converted to Cropland

Biomass Carbon density

When land is converted to cropland, average biomass carbon density of the land following the transition should be subtracted from average carbon density of cropland to calculate carbon emissions due to the conversion. For other land categories, the pre-transition carbon density will depend on land sub-category. The parameters are summarized below in Table 30.

Table 30. Carbon density parameters for Land Converted to Croplands. References provided in each land category section.

Converted from	Pre-transition C density (tonne C $acre^{-1}$)	Converted to	Post-transition C density (tonne C $acre^{-1}$)
Forest	See Table 14, Table 15, and Table 16 for C stocks for each forest sub-category	Cropland	Orchards - 2.58 Berries - 4.64 Annual crops – 1.9 Forage crops/pasture – 2.73
Grassland	AGB: 0.714 BGB: 0.079		
Wetlands	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25 Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47 Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47 Estuarine Emergent Wetland – AGB: 1.25/BGB: 2.65		
Settlement	Open space – AGB: 11.8/BGB: 2.0 Low intensity development – AGB: 27.1/BGB: 4.4 Medium intensity development – AGB: 20.9/BGB: 3.7 High intensity development – AGB: 30.8/BGB: 4.2		
Other Land	0		

Soil organic carbon in mineral soils

Fluxes in SOC in mineral soils (not inclusive of histosols taxonomic order) are expected to occur when land is converted. For mineral soils, IPCC default assumption is that it takes 20 years to reach a new equilibrium from the time management changed. However, since currently New Jersey doesn’t track land transitions over 20 years, it is assumed that change in mineral soil carbon occurs in the year of transition. IPCC Tier 1 parameters will be used to estimate SOC selected from the parameters listed in Table 31. Emission estimates should be entered in the NJ NWL Forest Land Calculator (See NJ NWL Calculator Manual, Section: Cropland Calculator/Emission Estimates - 11).

Table 31. Soil carbon stock change factors for Land Converted to Cropland to be applied to SOC_{REF} at 30 cm depth (Reference: 2019 Refinement to IPCC Guidelines, 2013 Wetland Supplement to IPCC Guidelines).

Converted from	Pre-transition stock change factors			Converted to	Post-transition stock change factors		
	F_{LU}	F_{MG}	F_I	Crop type	F_{LU}	F_{MG}	F_I
Forest [a] Grassland [a]	1	1	1	Row crops [a]	0.69	1	1
				Vegetable crops [a]	0.69	1	0.92
				Forage crops [a]	0.82	1.1	1
				Orchards/berries [a]	0.72	1.1	1
				Permanent pasture [a]	1	1	1
				Other cropland [a]	0.69	1	0.92
Settlements [b]	0.69	1	1	Row crops	0.69	1	1
Wetlands – inland on mineral soils [c]	1	1	1	Row crops	0.71	1	1
Other land [d]	NE	NE	NE		NE	NE	NE

[a] For forest land and grassland converted to cropland, land is disaggregated according to the same proportions as cropland remaining cropland for that year, conventional tillage is assumed for all annual crops

[b] For settlements converted to cropland, it is assumed that settlements and croplands have similar F_{LU} stock change factors due to disturbance, conversion to cultivated land use with conventional tillage and medium input assumed

[c] For inland wetlands on mineral soils converted to cropland, conversion to cultivated land use with conventional tillage and medium input assumed, F_{LU} for cropland on inland wetland mineral soils (Reference: IPCC 2013 Wetland supplement, Ch. 5, Table 5.3)

[d] For other land converted to cropland, SOC flux is not estimated

Emissions from Drained Organic Soils (all cropland)

Cropland occurring on organic soils (histosols taxonomic order) are assumed to be drained and would continue to emit CO_2, N_2O, and CH_4. The same parameters are used to estimate emissions for cropland remaining cropland and land converted to cropland. The emission factors are provided in Table 32. Emission parameters for drained organic soils are entered in the NJ Cropland calculator (see NJ NWL Calculator Manual, Section: Cropland Calculator/Land area – 8, Note emission factors for drained organic soil emissions are entered in the same sheet as the land area).

Table 32. Emission factors for drained organic soils on Cropland (Reference: IPCC 2013 Wetland Supplement, Chap 2).

Parameter	Gas	Value	Unit	Converted value	Unit
EF, direct emissions	CO_2	7.9 (6.5 – 9.4)	tonne CO_2-C hectare^{-1} year^{-1}	3.197	tonne CO_2-C acre^{-1} year^{-1}
EF, indirect emissions	CO_2	0.31 (0.19–0.46)	tonne C hectare^{-1} year^{-1}	0.125	tonne C acre^{-1} year^{-1}
EF, direct emissions	N_2O	13 (8.2 – 18)	kg N_2O-N hectare^{-1} year^{-1}	0.00526091	tonne N_2O-N acre^{-1} year^{-1}
EF, land	CH_4	0 (-2.8 – 2.8)	kg CH_4 hectare^{-1} year^{-1}	0	tonne CH_4 acre^{-1} year^{-1}
EF, ditch	CH_4	1165 (335-1995)	kg CH_4 hectare^{-1} year^{-1}	0.471	tonne CH_4 acre^{-1} year^{-1}
Frac_ditch	CH_4	0.05	unitless	0.05	Unitless
Values in () represent 95% confidence interval					

Calculations

Carbon fluxes and non-CO_2 emissions are calculated automatically by the New Jersey Cropland calculator when activity data and emission parameters are entered by the user (see NJ NWL Calculator Manual, Section: Cropland Calculator/Emission estimates). Net GHG emissions and removals are calculated annually for each land category using the following approaches, consistent with the 2006 IPCC Guidelines:

- Stock-Difference Approach: Used for estimating C fluxes for soil and biomass carbon pools, where change is estimated as the difference in stocks at two points in time.
- When land is converted to cropland, is assumed that it is converted with the same proportional distribution of crop systems as in cropland remaining cropland
- When land is converted to cropland, is assumed that all biomass C is lost due to land clearance and removal of vegetation
- CO_2 and non-CO_2 (methane and nitrous oxide) emissions from drained soils are estimated by multiplying Cropland area by emission factor for all cropland

The C fluxes and non-CO_2 emissions are estimated by the New Jersey Cropland Calculator according to the following formulas. Note that emission factors in section above are provided in units in which they were derived and published. Activity data are converted by the calculator to the proper units, as needed.

Cropland remaining Cropland

Biomass Carbon Flux (for perennial woody crops only)

Biomass C flux is calculated for perennial woody crops only because annual crops are assumed to not be accumulating carbon from year to year, therefore C stocks are not changing. C stock for each year for each crop type (orchards, berries) is estimated and subtracted from the previous year to obtain the C flux.

Equation 11. CRC Biomass Carbon Flux for Orchard Crops

$$Orchards: Biomass\ carbon\ flux\ (tonne\ C\ year^{-1}) = (-1) \times ((\text{Orchard area}(acre)_t \times\ Orchard\ biomass\ carbon\ density) - (\text{Orchard area}\ (acre)_{t-1} \times\ Orchard\ biomass\ carbon\ density))$$

Where t is the current year of the inventory, t-1 is the previous year of the inventory

Equation 12. CRC Biomass Carbon Flux for Berry Crops

$$Berries: Biomass\ carbon\ flux\ (tonne\ C\ year^{-1}) = (-1) \times ((\text{Berries area}(acre)_t \times\ Berries\ biomass\ carbon\ density) - (\text{Berries area}\ (acre)_{t-1} \times\ Berries\ biomass\ carbon\ density))$$

Where t is the current year of the inventory, t-1 is the previous year of the inventory

The total biomass carbon flux for cropland remaining cropland is the sum of stock changes due to all woody crops. C is converted to CO2 by multiplying by (44/12).

Soil Carbon Flux

SOC flux in mineral soil is calculated using *Equation 1* with the assumption that change occurs in the year of transition, so C stock change is not divided by 20.

Land converted to cropland

Biomass Carbon Stock Change (conversion)

When land is converted to cropland, all the biomass pre-conversion is assumed to be lost in the year of transition.

Equation 13. LCC Biomass Carbon Stock Change from conversion

$$Biomass\ C\ Flux\ (tonne\ C\ year^{-1}) = \text{Land converted to cropland area}\ (acre) \times Biomass\ Carbon\ Density_{pre-transition}$$

Equation 14. LCC Biomass Carbon gain post conversion

$$Biomass\ C\ Flux\ (tonne\ C\ year^{-1}) = (-1) \times \text{Land converted to cropland area}\ (acre) \times Biomass\ Carbon\ Density_{post-transition}$$

The total biomass carbon flux for land converted to cropland is the sum of stock changes due to conversion and biomass gains. C is converted to CO2 by multiplying by (44/12).

Soil organic carbon flux

SOC flux in mineral soil is calculated using

Equation 1 with the assumption that change occurs in the year of transition, so C stock change is not divided by 20.

NOTE: SOC flux is estimated for newly converted land each year, which is linearly interpolated between datasets. Therefore, SOC flux is equal for each year within a period between datasets.

Drained organic soil emissions

Annual emissions are estimated for each gas for each year in the time series, converted to CO2e and totaled.

CO_2 emissions from drained soils

Equation 15. Drained Organic Soils on-site CO2 emissions

a. $$Annual\ on-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ cropland\ area\ (acre) \times\ EF$$

Equation 16. Drained Organic Soils off-site CO2 emissions

b. $$Annual\ off-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ cropland\ area\ (acre) \times\ EF$$

NOTE: convert CO_2-C to CO_2 (44/12)

N_2O emissions from drained soils

Equation 17. Drained Organic Soils N2O emissions

$$N_2O\ emissions\ from\ drained\ soils\ [(tonne\ N_2O-N\ year^{-1}) = Drained\ cropland\ area\ (acres) \times\ EF]$$

NOTE: convert N_2O-N to N_2O (44/28)

CH_4 emissions from drained soils

Equation 18. Drained Organic Soils CH4 emissions

$$CH_4\ emissions\ from\ drained\ soils\ (tonne\ CH_4\ year^{-1}) = \left\{ Drained\ cropland\ area\ (acres)\ \times \begin{bmatrix} \left((1-Frac_{ditch}) \times EF_{land}\right) \\ + \\ \left((Frac_{ditch}) \times EF_{ditch}\right) \end{bmatrix} \right\}$$

Emissions are provided for cropland remaining cropland and land converted to cropland for each Anderson sub-class, and by carbon pool as applicable. The summary tab in the Cropland Calculator provides total emission by main categories.

Uncertainty

Uncertainty associated with cropland stratification is high because they are derived from data sourced from US Agriculture Census for only a subset of the years in the timeseries. Furthermore, only proportional allocation is possible and utilized for major cropping categories – row crops, vegetable crops, forage crops, orchards, berries, and other. Similarly, stratification of cropland by management is also based on proportional or categorical allocation from the US Ag Census or literature. Data is averaged across the state and does not permit spatial differentiation or differentiation by cropping systems.

Underlying uncertainties in the estimates of biomass and soil carbon stock changes in Cropland include uncertainties associated with values for biomass carbon stocks, soil organic carbon stocks and stock change factors, and emissions factors for drained organic soils. SOC reference values are averaged across soil taxonomies, resulting in a state average SOC_{REF} for all mineral soils and for organic soils. For all parameters, error/SD is provided, however, uncertainty is potentially propagated and increased due to the uncertainties described above associated with land stratification. Uncertainty associated with default parameters utilized in the calculations (orchard biomass C, stock change factors for mineral soils, drained organic soils) is propagated.

Furthermore, assumptions on temporal dynamics that underlie the methodological approaches applied lead to uncertainty. When land management changes or land is converted from other land uses to cropland, soil carbon stocks may take 20 years or more to reach equilibrium. Currently, we assume that the change occurs in the year of transition because 20-year transitions are not tracked. This results in C flux appearing in 1 year rather than spread out over a 20-year period which may appear as an overestimation. If the land conversion is maintained over the long term, the C flux trend, averaged over time, will balance out.

Future improvements

Refine classification

It is recommended that the area of pastureland is disaggregated from cropland for separate accounting in the in the future to improve accounting for SOC fluxes in mineral soils. Furthermore, cropland should be further differentiated into sub-categories that allows stratification by cropping systems (e.g., row crops, vegetable crops, perennial crops (herbaceous and woody).

Activity data

Furthermore, data on management would help improve estimation of mineral SOC fluxes if data on tillage and inputs was available for each cropping system that is available. Currently the data is based on information from the UA Agriculture Census and applies numerous assumptions.

Improving emission parameters

Currently, Tier 1 parameters are used in estimating changes in orchard biomass and SOC. Improving estimates of biomass carbon fluxes requires stratification of cropland areas according to cropping and management practices as outlined above. With such information, SOC changes could be modeled using existing tools such as Comet Farm. Also, measurements on biomass densities and accumulation rates in perennial crops would improve estimates of biomass C fluxes.

GRASSLANDS

Grassland definitions

According to the IPCC Guidelines, the grassland category includes rangelands and pasture land that are not considered the Cropland category. The NJ LULC dataset currently omits the rangeland category. Furthermore, pastureland is aggregated together with croplands. However, for GHG accounting purposes, it is good practice to differentiate land with perennial herbaceous and/or woody vegetation due to distinct processes that may be driving emissions or removals of GHGs. Therefore, for the purpose of the NWL inventory, lacking a formal definition of grassland at the state level, sub-categories that align with relevant vegetation characteristics were reclassified to the extent possible and assigned to the Grassland category, to enable consistency with national definitions. The following categories are accounted for in the Grassland category:

- Carbon fluxes in Grassland remaining Grassland (by carbon pool)
- Carbon fluxes in Land Converted to Grassland (by carbon pool)

Considering the national definition used in the NGHGI, grasslands are defined as land with plant cover composed principally of grasses, grass-like plants (i.e., sedges and rushes), forbs, or shrubs suitable for grazing and browsing, and includes both pastures and native rangelands (EPA 2024). It is recommended that GHG emissions and removals occurring on sub-classes of land that are characterized by grass and shrub vegetation be accounted for in the Grassland category.

This category includes GHG emissions and removals due to changes in biomass and soil C stocks.

Organic soils, of histosols taxonomic order, on grassland are identified separately from other grassland soils largely because mineralization of the exposed or partially dried organic material results in continuous CO_2 and N_2O emissions (IPCC 2006). In addition, the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014) calls for estimating CH_4 emissions from these drained organic soils and the ditch networks used to drain them. All organic soils are assumed to be undrained although some drainage may be occurring. Emissions are not estimated due to lacking data on drainage practices.

Data flow for compilation of the emissions and removals for grasslands is shown in Figure 9.

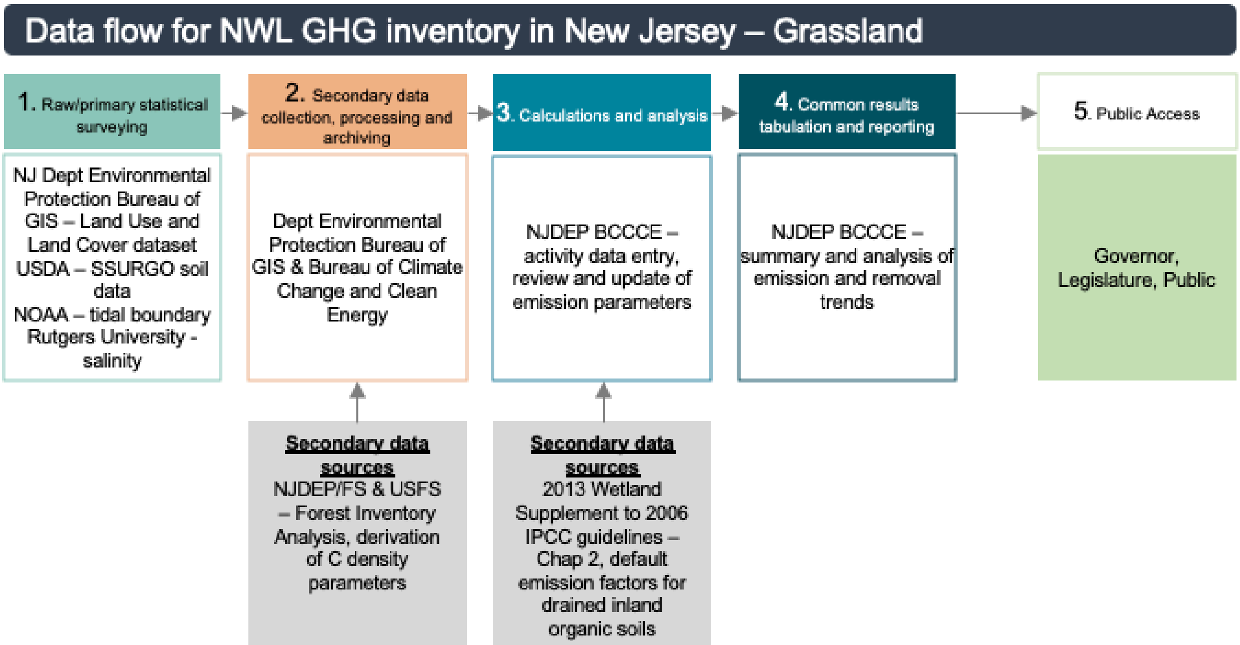

Figure 9. Data flow for NWL GHG inventory in New Jersey for the Grassland category

Activity Data

Land area

The NJ LULC dataset currently does not utilize the rangeland class and combines cropland and pastureland into one sub-class under the agricultural land type. However, there are several sub-classes listed under the Forest type, that will be designated as grassland for the purposes of the NWL GHG inventory. As stated in Table 6, these include:

1. 4410: Old field (< 25% brush covered)
2. 4420: Deciduous brush/shrubland
3. 4430: Coniferous brush/shrubland
4. 4440: Mixed deciduous/coniferous brush/shrubland

For each year when an updated LULC dataset is available, the grassland area for each of the categories is prepared according to the steps outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning) and further disaggregated by grassland remaining grassland and land converted to grassland and soil type. All data entered in the New Jersey Grassland calculator must be in acres as the area units. Acres is also the unit from the source dataset. Therefore, no conversions are necessary. For step by step instructions see the NJ NWL Calculator Manual (Section: Grassland Calculator/Land Area 1-6).

Stratification by land use and management

Soil carbon fluxes on mineral soils can occur due to conversion of land use or change in management. Land converted to grassland is already disaggregated by pre-transition land use to estimate changes in carbon stocks in mineral soils. Currently, activity data on management practices, for example, area of grassland with improved management or grazing is not available, therefore no additional stratification is done.

Stratification by soil type

All grasslands are disaggregated by soil taxonomic order into mineral or organic soils. Data on taxonomic order was taken from the USDA SSURGO dataset (retrieved May 2025). See cross-cutting section for the steps on data preparation and processing. Area of grassland occurring on mineral and organic soils is entered as activity data following instructions in the NJ NWL Calculator Manual (Section: Grassland Calculator/Land Area 7-8).

Soil organic carbon (SOC) fluxes occur due to changes in management and land conversion. For grassland remaining grassland, SOC flux is not estimated due to lack of management data. For land converted to grassland, occurring on mineral soil, SOC fluxes are estimated using approach described in the cross-cutting section (see Equation 1). Emissions from organic soils are not estimated due to lacking of data on the proportion of land that is drained, however activity data for area of forest on organic soils is entered to allow future calculations.

Emission Factors

Grassland Remaining Grassland

Biomass Carbon density

Carbon density factors are generated for aboveground biomass and belowground biomass carbon pools in the grassland based on data from the network of periodic and annual national forest inventory (NFI) plots established and measured by the Forest Inventory and Analysis (FIA) program within the USDA Forest Service. FIA plots collected from the state of New Jersey will be used for estimating carbon density for aboveground and belowground biomass. New Jersey FIA plots are remeasured every 5 years and provide C measurement data for live seedlings, shrubs, and bushes in New Jersey. FIA data is queried using EVALIDator website (https://apps.fs.usda.gov/fiadb-api/evalidator) using the parameters provided in Table 33. Data is downloaded as a .CSV file to obtain total carbon density for all sub-classes of grasslands.

Table 33. Carbon density query parameters for EVALIDator

EVALIDator Selection Parameters	User Selection
Land basis:	Forest land
Numerator estimation group:	Carbon
Denominator estimation group:	Area
Press continue	
Numerator attribute number and description: *Note: Two files must be downloaded separately for each of the carbon pools. Follow all steps to obtain the tabular parameters.*	48 – Aboveground carbon in live seedlings, shrubs, and bushes in short tons, on forest land 49 – Belowground carbon in live seedlings, shrubs, and bushes in short tons, on forest land

EVALIDator Selection Parameters	User Selection
Denominator attribute number and description:	0002 Area of forest land, in acres
Forest land definition:	FIADEF
Inventories:	Show all available inventories
Press continue	
State/EVAL_GRP(s):	New Jersey 342022 (current inventory 2018-2022)
Press continue	
Page variable:	None
Page temporal basis:	Current
Row variable:	All live stockings (based on values from the Current inventory), Total is used
Row temporal basis:	Current
Column variable:	All live stockings (based on values from the Current inventory), Total is used
Column temporal basis:	Current
Output format:	*Download normalized estimates in CSV*

The carbon density values are summarized in Table 34. These are used to estimate emissions and removals for all sub-classes used in the activity data for woody shrub vegetation. Biomass in herbaceous vegetation grows and decays annually, therefore it is assumed that there is no accumulation of carbon in annual and perennial grasses that occur.

Table 34. New Jersey carbon densities for estimating carbon stocks and fluxes in grassland remaining grassland based on FIA data. Note: same parameters are applied to all grassland sub-categories due to data limitations, however, they can be updated if/when new information becomes available; ± value represents the 95% confidence interval

Grassland sub-class	AGB Carbon density		BGB Carbon density	
	Short dry ton C acre^{-1}	Tonne C acre^{-1}	Short dry ton biomass acre^{-1}	Tonne C acre^{-1}
	A	B=A*0.907	C	D=C*0.907
Old field (< 25% brush covered)	0.789 ± 0.01	0.714	0.088 ± 0.001	0.079
Deciduous brush/shrubland	0.789 ± 0.01	0.714	0.088 ± 0.001	0.079
Coniferous brush/shrubland	0.789 ± 0.01	0.714	0.088 ± 0.001	0.079
Mixed deciduous/coniferous brush/shrubland	0.789 ± 0.01	0.714	0.088 ± 0.001	0.079

Emission parameters presented in Table 34 should be entered in the NJ NWL Grassland Calculator (See NJ NWL Calculator Manual, Section: Grassland Calculator/Emission Factors - 9).

Soil Carbon on Mineral Soils

Activity data on management is not available to allow estimation of soil carbon fluxes at this time (for example, if an old field would be considered “degraded” or “nominally managed” to justify application of different soil carbon stock change parameters). All grasslands are assumed to be nominally managed. Therefore, it is assumed that SOC fluxes on mineral soils in grasslands remaining grasslands are 0.

Land converted to Grassland

Biomass Carbon density

When an acre of forest is converted to an acre of grassland, average biomass carbon density of grassland should be subtracted from average carbon density of forest to calculate carbon emissions due to conversion of forest to grassland. For other land use types, biomass carbon density for land converted to grassland will be biomass carbon density of the original land use type minus carbon density for the grassland. The parameters are summarized below in Table 35. Emission parameters presented in Table 35 should be entered in the NJ NWL Grassland Calculator (See NJ NWL Calculator Manual, Section: Grassland Calculator/Emission Factors - 9).

Table 35. Carbon density parameters for Land Converted to Grasslands. References provided in each land category section.

Converted from	Pre-transition C density (tonne C acre^{-1})	Converted to	Post-transition C density (tonne C acre^{-1})
Cropland	Orchards - 2.58 Berries - 4.64 Annual crops – 1.9 Forage crops/pasture – 2.73		
Forest	See Table 14, Table 15, and Table 16 for C stocks for each forest sub-category	Grassland	AGB: 0.714 BGB: 0.079
Wetlands	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25 Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47 Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47 Estuarine Emergent Wetland – AGB:1.25/BGB:2.65		
Settlement	Open space – AGB: 11.8/BGB: 2.0 Low intensity development – AGB: 27.1/BGB: 4.4 Medium intensity development – AGB: 20.9/BGB: 3.7 High intensity development – AGB: 30.8/BGB: 4.2		
Other Land	0		

Soil Carbon on mineral soils

Fluxes in SOC in mineral soils (not inclusive of histosols taxonomic order) are expected to occur when land is converted. For mineral soils, IPCC default assumption is that it takes 20 years to reach a new equilibrium from the time management changed. However, since currently New Jersey does not track land transitions over 20 years, it is assumed that change in mineral soil carbon occurs in the year of transition. A combination of IPCC Tier 1 and 2 parameters will be used to estimate SOC selected from the parameters listed in Table 36. If or when data on grassland management becomes available, the corresponding stock change parameters for Grasslands are available in the Annex. Emission parameters presented in Table 36 should be entered in the NJ NWL Grassland Calculator (See NJ NWL Calculator Manual, Section: Forest Land Calculator/Emission Estimates - 13).

Table 36. Soil Carbon stock change factors for Land Converted to Grassland (Reference: 2019 Refinement to IPCC Guidelines, 2013 Wetland Supplement to IPCC Guidelines).

Converted from	Pre-transition stock change factors			Converted to	Post-transition stock change factors		
	F_{LU}	F_{MG}	F_I		F_{LU}	F_{MG}	F_I
Cropland – long term cultivated [a]	0.69	1	1	Grassland	1	1	1
Cropland – set aside [a]	0.82	1	1		1	1	1
Cropland – perennial/tree crop [a]	0.72	1	1		1	1	1
Cropland – pastureland [a]	1	1	1		1	1	1
Forest [b]	1	1	1		1	1	1
Wetlands – inland on mineral soils [c]	1	1	1		0.71	1	1
Settlements [d]	0.69	1	1		1	1	1
Other land [e]	NE	NE	NE		NE	NE	NE

[a] For Cropland converted to Grassland, same proportions as cropland remaining cropland are assumed, with long term cultivated = annual crops and other crops, set aside = forage crops, perennial/tree crop = orchard and berries, pastureland is the proportion of cropland that's permanent pasture and is treated as nominally managed grassland. It is assumed that conventional tillage and medium input cropping is representative of for all cropland converted

[b] For forest converted to grassland, nominally managed grassland is assumed, SOC is assumed to equal to SOC_{REF}

[c] SOC flux estimated for inland wetlands on mineral soils converted to forest, F_{LU} is assumed to be = to cropland with long-term cultivation

[d] For settlements, the same value as cultivated cropland is assumed

[e] For other land converted to forest land, SOC flux is not estimated

Emissions from Drained Organic Soils (all grasslands)

Grasslands occurring on organic soils (histosols taxonomic order) are assumed to be undrained, therefore, CO_2, N_2O, and CH_4 emissions are not estimated. This is a conservative assumption as there is knowledge of areas that have been drained. Parameters are provided for future use when proportion of organic soils that are drained have been estimated. The emission factors are provided in Table 37 from the 2013 Wetland Supplement, Chap. 2. Parameters for grasslands in temperate climate, nutrient rich soils with deep drainage were selected. Data characterizing drained organic soils in grasslands are currently not systematically collected and variability is expected. However, due to existence of bogs and fens in the state and general widespread use of fertilizers, it is assumed that soils are nutrient rich. There is currently no set threshold for designating soil nutrient rich or nutrient poor. Drainage class is defined as the mean annual water table averaged over a period of several years; the shallow-drained class is defined as the mean annual water table depth of less than 30 cm below the surface. The deep-drained class is defined as the mean annual water table depth of 30 cm and deeper below the surface (IPCC 2013, Wetland Supplement, Chap. 2). It is recommended to apply deep drainage parameters if data is not available as a default option. Steps to refine parameter choices are discussed in the Future Improvements section below. Emission parameters presented in Table 37 should be entered in the NJ Grassland Calculator (See NJ NWL Calculator Manual, Section: Grassland Calculator/Land Area – 8, Note emission factors for drained organic soil emissions are entered in the same sheet as the land area). The proportion of the organic soils will also need to be entered in the NJ Grassland Calculator.

Table 37. Emission factors for drained organic soils on Grassland. (Reference: IPCC 2013 Wetland Supplement, Chapter 2). Values in () represent the 95% confidence interval.

Parameter	Gas	Drainage	Nutrient level	Value	Unit	Converted Value	Unit
EF, direct emissions	CO_2	Deep	Nutrient rich	6.1 (5.0 – 7.3)	tonne CO_2-C hectare^{-1} year^{-1}	2.469	tonne CO_2-C acre^{-1} year^{-1}
EF, indirect emissions	CO_2	NA	NA	0.31 (0.19–0.46)	tonne C hectare^{-1} year^{-1}	0.125453	tonne C acre^{-1} year^{-1}
EF, direct emissions	N_2O	Deep	Nutrient rich	8.2 (4.9 – 11)	kg N_2O-N hectare^{-1} year^{-1}	0.00331842	tonne N_2O-N acre^{-1} year^{-1}
EF, CH_{4_land}	CH_4	Deep	Nutrient rich	16 (2.4 – 29)	kg CH_4 hectare^{-1} year^{-1}	0.00647497	tonne CH_4 arce^{-1} year^{-1}
EF, CH_{4_ditch}	CH_4	Deep	NA	116 (335–1995)	kg CH_4 hectare^{-1} year^{-1}	0.0469435	tonne CH_4 arce^{-1} year^{-1}
$Frac_{ditch}$	CH_4	Deep		0.05	unitless	0.05	unitless

Calculations

Carbon fluxes are calculated automatically by the New Jersey Grassland calculator when activity data and emission parameters are entered by the user (see NJ NWL Calculator Manual, Section: Grassland Calculator/Emission estimates). Net GHG emissions and removals are calculated annually for each land category using the following approaches, consistent with 2006 IPCC Guidelines.

- Stock-Difference Approach: Used for soil carbon pools, where change is estimated as the difference in stocks at two points in time.
- For estimating SOC fluxes, it is assumed that all SOC stock changes in the year of transition (rather than in 20 years as IPCC Guideline state) because data currently does not track 20-year transitions and likely the change is long term.
- When cropland is converted to grassland, is assumed that the cropland with the same proportional distribution of crop systems as in cropland category is converted and it is all under conventional tillage and has medium levels of inputs
- CO_2 and non-CO_2 (methane and nitrous oxide) emissions from drained soils are estimated by multiplying grassland area by emission factor for all grasslands

The Carbon fluxes and non-CO_2 emissions are estimated by the New Jersey Grassland Calculator according to the following formulas. Note that emission factors in the section above are provided in units in which they were derived and published. Activity data is converted by the calculator to the emission factors and other parameters units, as needed.

Grassland remaining grassland

Biomass Carbon Flux

C stock for each year for each vegetation type is estimated and subtracted from the previous year to obtain the C flux.

Equation 19. GRG Biomass Carbon Flux

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = (-1) \times ((\text{Grassland remaining grassland area}\ (acre)_t \times\ Biomass\ C\ density) - (\text{Grassland remaining grassland area}\ (acre)_{t-1} \times\ Biomass\ C\ density\ ))$$

Where t is the current year of the inventory, t-1 is the previous year of the inventory.

C is converted to CO_2 by multiplying by (44/12).

Land converted to grassland

Biomass Carbon Stock Change (conversion)

When land is converted to grassland, all the biomass pre-conversion is assumed to be lost in the year of transition.

Equation 20. LCG Biomass Carbon Stock Change from conversion

$$Biomass\ C\ Flux\ (tonne\ C\ year^{-1}) = \text{Land converted to grassland area}\ (acre) \times Biomass\ C\ density_{Pre-transition}$$

Equation 21. LCG Biomass Carbon gain post conversion

$$Biomass\ C\ Flux\ (tonne\ C\ year^{-1}) = (-1) \times \text{Land converted to grassland area}\ (acre) \times Biomass\ Carbon\ Density_{post-transition}$$

The total biomass carbon flux for land converted to grassland is the sum of stock changes due to conversion and biomass gain. C is converted to CO_2 by multiplying by (44/12).

Soil organic carbon flux

SOC flux in mineral soil is calculated using Equation 1 (without dividing by 20)

NOTE: SOC flux is estimated for newly converted land each year, which is linearly interpolated between datasets. Therefore, SOC flux is equal for each year within a period between datasets.

Drained organic soil emissions

Annual emissions are estimated for each gas for each year in the time series, converted to CO2e and totaled.

CO_2 emissions from drained soils

Equation 22. Drained Organic Soils on-site CO2 emissions

a. $$Annual\ on-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ grassland\ area\ (acre) \times\ EF$$

Equation 23. Drained Organic Soils off-site CO2 emissions

b. $$Annual\ off-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ grassland\ area\ (acre) \times\ EF$$

NOTE: convert CO_2-C to CO_2 (44/12)

N_2O emissions from drained soils

Equation 24. Drained Organic Soils N2O emissions

$$N_2O\ emissions\ from\ drained\ soils\ [(tonne\ N_2O-N\ year^{-1}) = Drained\ grassland\ area\ (acres) \times\ EF]$$

NOTE: convert N_2O-N to N_2O (44/28)

CH_4 emissions from drained soils

Equation 25. Drained Organic Soils CH4 emissions

$$CH_4\ emissions\ from\ drained\ soils\ (tonne\ CH_4\ year^{-1}) = \left\{ Drained\ grassland\ area\ (acres)\ \times \begin{bmatrix} \left((1-Frac_{ditch}) \times EF_{land}\right) \\ + \\ \left((Frac_{ditch}) \times EF_{ditch}\right) \end{bmatrix} \right\}$$

Emissions are provided for grassland remaining grassland and land converted to grassland for each grassland Anderson sub-class, grassland remaining grassland and land converted to grassland for each classification, and by carbon pool as applicable. The summary tab in the Grassland Calculator provides total emission by main categories.

Uncertainty

Underlying uncertainties linked to the NJ LULC data and their interpretation of remote sensing imagery data are the main sources of uncertainty. Furthermore, the NJ LULC data does not have a distinct category that captures grasslands (Rangelands have been omitted from the classifications as they are not found in New Jersey). However, the IPCC definition of grasslands includes “rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and bushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.” Therefore, sub-categories that are categorized under forests as brushland and shrubland (vegetation height <20ft) are more consistent with the Grassland category and have been assigned to the Grassland category as opposed to the Forest Land category. On the other hand, pastureland is currently combined with other agricultural land, therefore it is not possible to include it in the Grassland category. The current level of disaggregation in land use data for agricultural lands prevents fully accounting for grasslands category emissions and removals.

Furthermore, uncertainties in the estimates of biomass carbon stock changes and non-CO_2 emissions in Grasslands include uncertainties associated with values for biomass carbon stocks and emissions factors for drained organic soils. For biomass carbon stock parameters, error/SD is provided for FIA measurements. Uncertainty associated with these parameters utilized in the calculations (drained organic soils, soil carbon stock change factors for land converted to forests, biomass C accumulations rates) is propagated. Because emissions from organic soils are not estimated, the overall emissions are underestimated as some drainage is expected to occur despite lacking systematic data.

Also, assumptions on temporal dynamics that underlie the methodological approaches applied lead to uncertainty. When land is converted from other land uses to grassland, soil carbon stocks may take 20 years or more to reach equilibrium. Currently, we assume that the change occurs in the year of transition because 20-year transitions are not tracked. This results in C flux appearing in 1 year rather than spread out over a 20-year period which may appear as an overestimation. If the land conversion is maintained over the long term, the C flux trend, averaged over time, will balance out.

Future improvements

Refine classification

It is recommended that the area of pastureland is disaggregated from cropland for separate accounting in the future to improve accounting for SOC fluxes in mineral soils. Furthermore, pasturelands should be further differentiated into lands that are largely undisturbed and are in natural state, to be included in the Grasslands category and those that are cultivated for production of forage crops, which should remain under the Cropland category.

Management data

To enable accounting of SOC fluxes in mineral soils, data on land conditions and management is needed. This includes information on area used for grazing or restoration activities as well as areas that may be degraded.

Improving emission parameters

Currently, information on biomass carbon stock is derived from FIA biomass data on live seedlings, shrubs, and bushes on forest lands. This is a proxy for biomass carbon in shrubs on grasslands. Improving estimates of biomass carbon fluxes requires additional collection of data and measurements on biomass densities and accumulation rates, for woody vegetation such as shrubs as well as perennial herbaceous vegetation. It would also be helpful to have more detailed information on proportion of shrub cover to obtain more accurate estimates of biomass Carbon.

To improve selection of parameters for estimating emissions from organic soils, assessment of proportion of area of drained organic soils is needed. Furthermore, it is recommended to analyze the water table depth in relation to areas with grasslands on drained organic soils and stratify land accordingly so that relevant emission factors can be applied. Regarding the nutrient level, it is likely for grasslands that are hydrologically isolated to be nutrient poor and those that are hydrologically connected to be nutrient rich. Spatial analysis could be conducted to stratify grassland areas by nutrient level. Determination of quantitative thresholds would require collection of soil cores in some representative areas that have different hydrologic characteristics and subsequent analysis to establish ranges for nutrient levels.

WETLANDS

The *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands ("Wetlands Supplement"*, IPCC 2014) provides procedures for quantification of GHG emissions and removals from wetlands. This methodology is accepted for estimating GHG emissions/removals in the Wetlands category in the NGHGI (US EPA 2024) and will also be applied to estimate GHG emissions and removals from New Jersey wetlands. Additional studies by Settlemyer et al. (2018) have identified emissions factors for New Jersey wetlands. The following categories are accounted for in the Wetland category:

- Carbon fluxes in Wetlands remaining Wetlands, coastal (by carbon pool)
- Carbon fluxes in Wetlands remaining Wetlands, inland (by carbon pool)
- Carbon fluxes in Land Converted to Wetlands (by carbon pool)
- Non-CO_2 emissions from drained organic soils (CH_4)

Definitions

The most recent NGHGI includes coastal wetlands from the state of New Jersey under the category of Land Use, Land-Use Change, and Forestry (LULUCF). Vegetated wetlands, unvegetated wetlands, and open water are included under the definition of wetlands. The NGHGI quantifies vascular plants' CO_2 sequestration in soils, biomass, litter, and dead wood stocks, along with methane emissions from water-logged soils. The NGHGI uses the stock change method for soil carbon and the gain-loss method for biomass and dead organic material. It does not account for the lateral flux of carbon into or out of wetlands. Seagrasses or seaweed (macroalgae) are not included in the NGHGI due to insufficient data on distribution or emissions factors. These two vegetation types are also not mapped in the NJ LULC dataset. Emissions from aquaculture are not estimated because statewide data on fish aquaculture production quantities are lacking. The methodology synthesizes best practices from established protocols while incorporating state-specific data sources and classification systems to ensure accuracy in wetland characterization and carbon stock assessment. Data flows for compiling emission and removal estimates for Wetlands are shown in Figure 10.

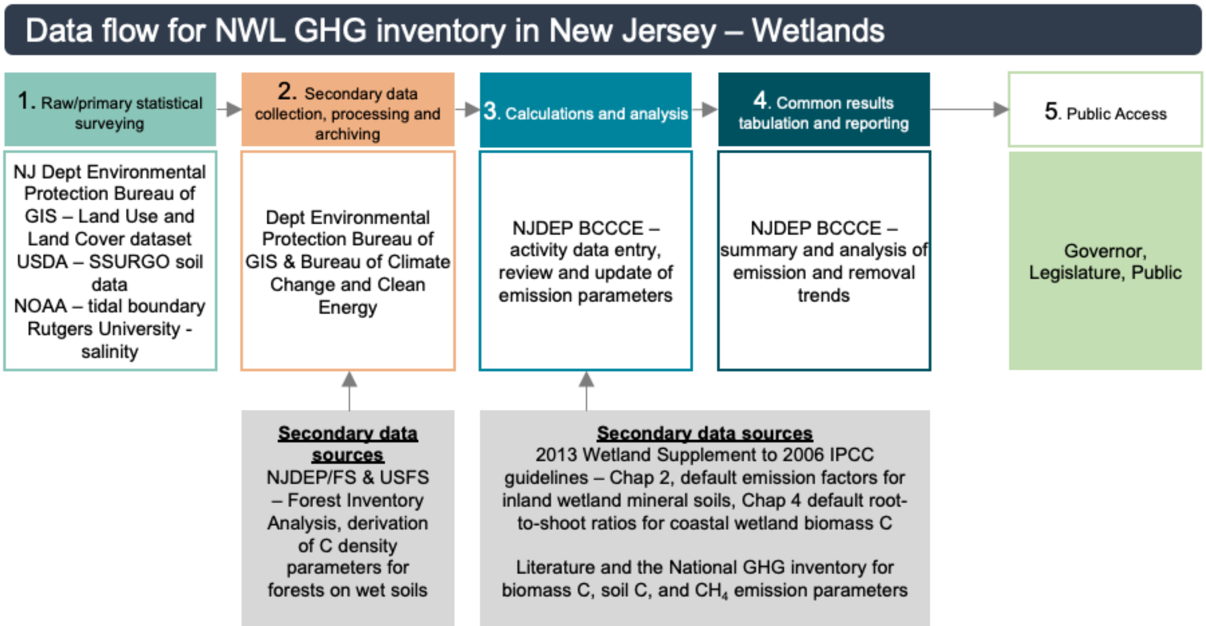

Figure 10. Data flow for NWL GHG inventory in New Jersey for the Wetland category

Activity data

Land area

Land use activity data and soil classification datasets are described above in the section on cross-cutting activity data.

The state inventory splits **coastal** wetlands and **inland**[10] wetlands because they have different emissions factors, particularly for methane production. New Jersey's Anderson classification has broad categories such as water and wetlands. Additional categories will be considered as wetlands as listed in Table 6 due to having saturated soil characteristics, for example, agricultural wetlands, which are classified as Agricultural land in the NJ LULC, but will be considered wetlands for the GHG inventory purposes. There are approximately 35 sub-classes of wetlands that would be included under the Wetland category (there may be slight variation from year to year due to wetlands of certain sub-types transitioning to another sub-type). Data is currently lacking to properly characterize and estimate emissions by each sub-class. Yet, each sub-category may have different characteristics and store different amounts of carbon, therefore activity data will be maintained at this disaggregation level to allow for future refinement of emission factors. To apply appropriate, currently available, emission factors in estimating emissions, New Jersey wetland sub-classes are assigned to a category based on the NOAA Coastal Change Analysis Program (CCAP; NOAA). The CCAP maps are available from 1996, 2001, 2006, 2010, and 2016 for the entire

[10] In this document, wetlands are divided based on their hydrological setting as coastal and inland based upon elevation related to Mean High Water Spring Tide. All inland wetlands are non-tidal but wetlands in coastal areas may be tidal or non-tidal, the latter occurring behind built infrastructure.

state of New Jersey at 30m resolution. Updated maps are released approximately every 5 years.

The LULC classes for wetlands used in the CCAP dataset include:

- Open water
- Palustrine aquatic bed
- Palustrine forested wetland
- Palustrine scrub/shrub wetland
- Palustrine emergent wetland (persistent)
- Estuarine aquatic bed
- Estuarine forested wetland
- Estuarine scrub/shrub wetland
- Estuarine emergent wetland

Geospatial Data Integration and Classification

New Jersey's approach to wetland inventory development centers on harmonizing data between the state's Land Use Land Cover (NJ LULC) dataset and NOAA's Coastal Change Analysis Program (CCAP) dataset to support blue carbon GHG inventory requirements.

To harmonize wetland mapping for New Jersey's blue carbon inventory, we integrated NJDEP's Land Use Land Cover (LULC) polygons with NOAA's CCAP raster categories, applying a robust, data-driven GIS overlay analysis using the periods 1995(1996) and 2015(2016). The selection of these two time periods allows us to assess the consistency and any potential temporal variation in classification correspondence across decades. Given the ecological complexity and lack of perfect one-to-one correspondence, a threshold-based classification system shown in Figure 11 was established to assign each LULC polygon to a single CCAP category. The threshold is used to ensure that the assigned class represents the clear majority of the polygon or pixel, minimizing misclassification. The 30–70% "Partial Revision" window flags transitional or mixed areas for further review, while <30% is considered too uncertain for reliable assignment (Green et al 2021). Green et al. (2021) recommend assigning the dominant or majority class for inventory reporting and stress the need for transparent documentation of the criteria used.

- ✓ Confirmed: >70% overlap between an LULC polygon and a single CCAP class. The polygon is confidently assigned to that CCAP category.
- Partial Revision (30–70% Overlap), the LULC polygon was assigned to the CCAP class with the highest overlap—even if it did not constitute a clear majority. This ensures categorical completeness for the inventory, but the assigned status is marked as "Partial Revision" and highlighted for future expert review
- Minor Overlap (<30%): LULC classes with less than 30% overlap with any CCAP category are **not assigned** and are reported for transparency and flagged for further assessment or possible reclassification if new data arise (see Table 38)

To decision tree used to assign New Jersey classes to CCAP categories is shown in Figure 11. The flowchart follows standard decision tree methodology used in geospatial analysis and classification used, where diamond shapes represent decision points with YES/NO conditions, rectangular shapes represent process steps and outcome, and directional arrows with YES/NO labels guide the decision pathway. Sequential logic shows how threshold values (>70%, 30-70%, <30%) determine assignment outcome:

- If >70% overlap with a single CCAP class, assign polygon to that CCAP category and mark as "✓ Confirmed."
- If 30–70% overlap with any CCAP class, assign polygon to the CCAP class with greatest overlap, mark as "Δ Partial Revision" (flag for future review; often reflects ecotonal/mixed systems).
- If <30% overlap with any CCAP class, do not assign polygon in the main inventory, mark as "Not Assigned/Δ Minor Overlap," and report for transparency and reassess with future data.

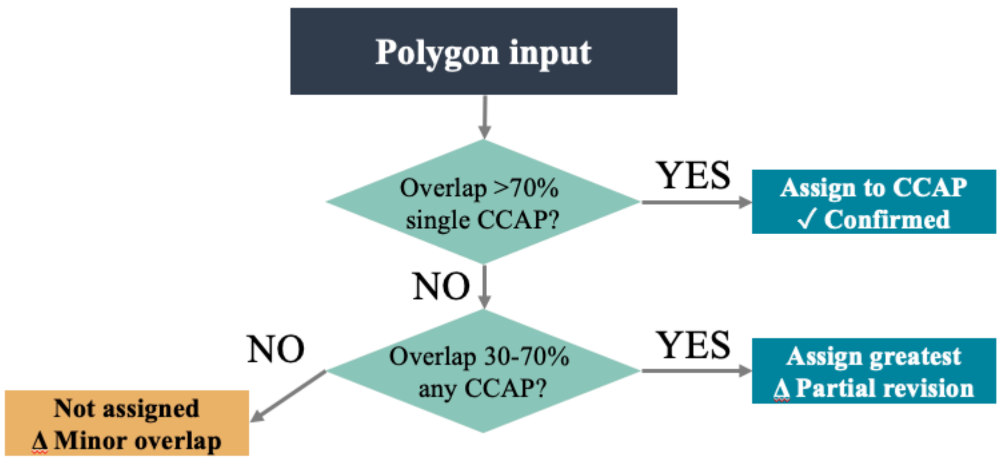

Figure 11. Flowchart demonstrating the decision tree for assigning CCAP classification to NJ LULC categories based on spatial overlap.

Table 38. Mapping of NJ LULC categories to CCAP classification

CCAP Name	LULC Class	Validation Status	% Overlap 1995	% Overlap 2015
Open Water	Artificial Lakes	✓ Confirmed	100%	94%
Open Water	Atlantic Ocean	✓ Confirmed	100%	99%
Open Water	Natural Lakes	✓ Confirmed	100%	97%
Open Water	Streams and Canals	✓ Confirmed	100%	98%
Open Water	Open Tidal Bays	✓ Confirmed	100%	99%
Open Water	Tidal Rivers, Inland Bays	✓ Confirmed	100%	99%
Open Water	Dredged Lagoon	✓ Confirmed	100%	93%
Palustrine Forested Wetland	Coniferous Wooded Wetlands	✓ Confirmed	82%	87%
Palustrine Forested Wetland	Deciduous Wooded Wetlands	✓ Confirmed	95%	92%
Palustrine Forested Wetland	Mixed Wooded Wetlands (Conif/Decid)	✓ Confirmed	100%	85–89%
Palustrine Forested Wetland	Atlantic White Cedar Wetlands	✓ Confirmed	80%	96%

Palustrine Forested Wetland	Disturbed Wetlands (Modified)	✓ Confirmed	100%	85%
Palustrine Forested Wetland	Wetland Rights-of-Way	✓ Confirmed	61%	88%
Palustrine Forested Wetland	Severe Burned Wetland Vegetation	✓ Confirmed	100%	94%
Palustrine Scrub/Shrub Wetland	Coniferous Scrub/Shrub Wetlands	Δ Partial Revision	96%	56%
Palustrine Scrub/Shrub Wetland	Deciduous Scrub/Shrub Wetlands	Δ Partial Revision	100%	48%
Palustrine Scrub/Shrub Wetland	Mixed Scrub/Shrub Wetlands (Conif/Decid)	Δ Partial Revision	53–100%	51–53%
Palustrine Emergent Wetland	Freshwater Tidal Marshes	Δ Partial Revision	100%	39%
Palustrine Emergent Wetland	Herbaceous Wetlands	Δ Partial Revision	100%	42%
Palustrine Emergent Wetland	Phragmites Dominate Interior Wetlands	✓ Confirmed	100%	67%
Palustrine Emergent Wetland	Managed Wetland in Built Areas	Δ Minor Overlap	n/a	<30%
Estuarine Emergent Wetland	Saline Marshes (High/Low)	✓ Confirmed	100%	98–99%
Estuarine Emergent Wetland	Phragmites Dominate Coastal Wetlands	Δ Partial Revision	n/a	73%
Estuarine Emergent Wetland	Freshwater Tidal Marshes	Δ Partial Revision	73%	61%
Estuarine Emergent Wetland	Disturbed Tidal Wetlands	✓ Confirmed	n/a	82%
Palustrine Aquatic Bed	[No consistently validated classes]	Δ Minor Overlap	<1%	<1%
Estuarine Aquatic Bed	Tidal Mud Flat/Exposed Flats	Δ Minor Overlap	<1%	<1%

Figure 12 enables rapid evaluation of which NJ LULC classes are best represented within each CCAP category and highlights category richness or dominance patterns relevant for inventory and management purposes. Each colored section represents a different CCAP class, and the boxes within it show the proportional area contributed by each NJ LULC class. It should be noted that some categories are assigned to a CCAP class despite low level of overlap, which adds uncertainty to the results.

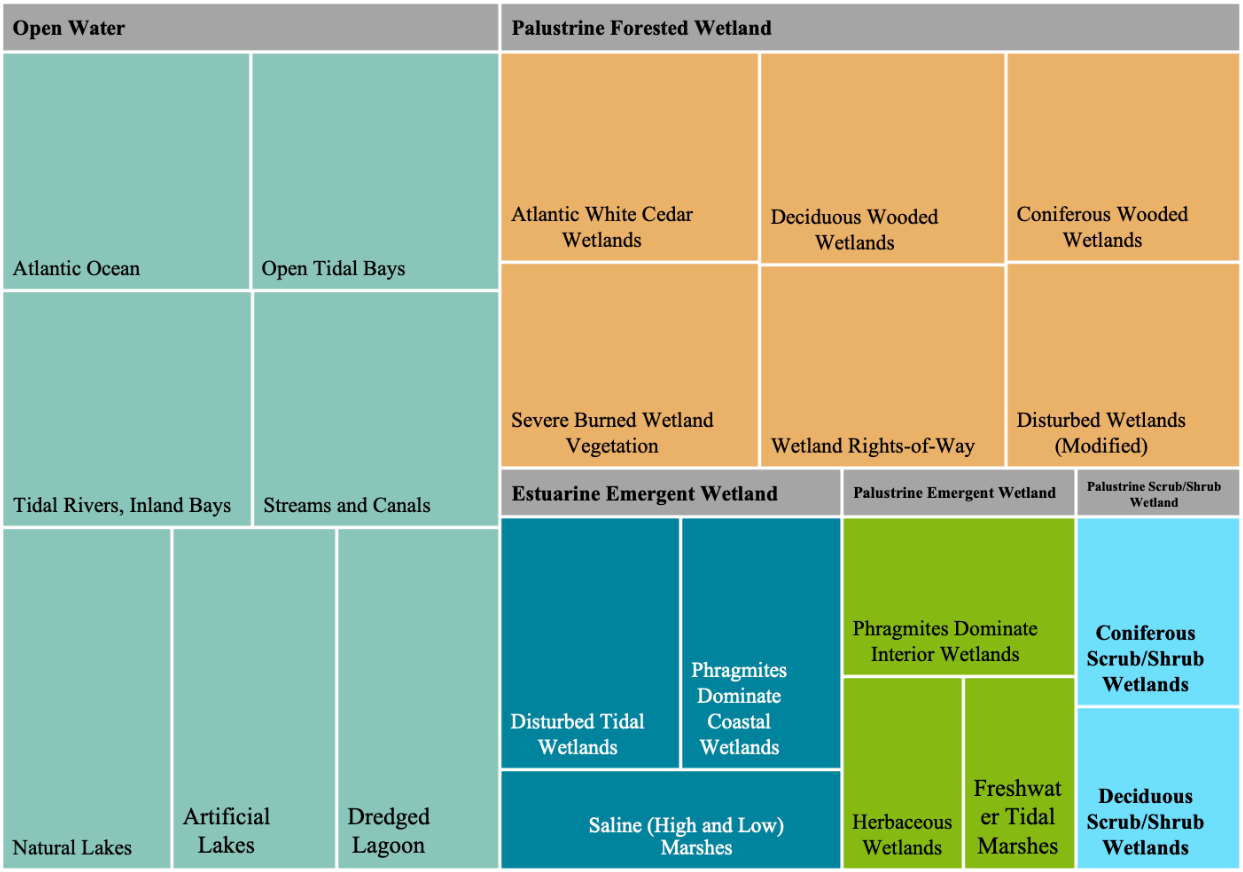

Figure 12. Visual representation of data provided in Table 39 showing assignment of New Jersey LULC wetland classes (colored blocks) to CCAP classification system (gray blocks) and their proportional spatial contribution.

The analysis revealed that most NJ LULC classes fall within the palustrine forested wetland category of the CCAP classification system. Several categories utilized in the NJ LULC dataset, e.g., “Managed Wetland In Built-Up Maintained Rec Area” do not overlap with any CCAP categories. Those were assigned CCAP categories based on expert judgement. It is recommended that assignment of NJ LULC sub-classes to CCAP categories remains unchanged for subsequent inventories (i.e., analysis does not need to be repeated for future inventory cycles) unless new data becomes available that enables derivation of new emission factors for wetland subclasses in New Jersey. The resulting mapping is presented in Table 39. See the NJ NWL Calculator Manual (Section: Wetlands Calculator/Documentation) for configuring the mapping of NJ LULC wetland classes to CCAP within the NJ Wetland Calculators. Note that this documentation tab is included in all NJ NWL calculators and must be consistent across all calculators because it is used to assign emission factors for estimating emissions and removals for all existing wetland areas, lands that have been converted to wetlands, as well as wetlands that have been converted to other land categories. Once configured, the New Jersey Wetland Calculators will automatically assign each NJ LULC sub-class to the appropriate CCAP category based on the configuration within the calculators documentation tab.

Table 39. Assignment of New Jersey wetland LULC classes and CCAP classification using 1995 – 1996 and 2015-2016 periods.

NJ LULC Wetland Classifications	CCAP Classification
Artificial Lakes **Atlantic Ocean** **Dredged Lagoon** **Exposed Flats** **Natural Lakes** **Open Tidal Bays** **Streams And Canals** **Tidal Mud Flat** **Tidal Rivers, Inland Bays, And Other Tidal Waters** **Unvegetated Flats**	Open Water
Not Assigned	Palustrine Aquatic Bed (key assumption – vegetation will come back to disturbed areas)
Agricultural Wetlands (Modified)* **Atlantic White Cedar Wetlands** **Coniferous Wooded Wetlands** **Deciduous Wooded Wetlands** **Disturbed Wetlands (Modified)** **Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)*** **Managed Wetland In Built-Up Maintained Rec Area*** **Managed Wetland In Maintained Lawn Greenspace*** **Mixed Wooded Wetlands (Deciduous Dom.)** **Mixed Wooded Wetlands (Coniferous Dom.)** **Severe Burned Wetland Vegetation** **Wetland Rights-Of-Way**	Palustrine Forested Wetland
Coniferous Scrub/Shrub Wetlands **Deciduous Scrub/Shrub Wetlands** **Mixed Scrub/Shrub Wetlands (Coniferous Dom.)** **Mixed Scrub/Shrub Wetlands (Deciduous Dom.)**	Palustrine Scrub/Shrub Wetland
Freshwater Tidal Marshes **Herbaceous Wetlands** **Phragmites Dominate Interior Wetlands** **Phragmites Dominate Old Field (< 25% Brush Covered)** **Phragmites Dominate Urban Area**	Palustrine Emergent Wetland (Persistent)
Not Assigned	Estuarine Aquatic Bed
Not Assigned	Estuarine Forested Wetland
Not Assigned	Estuarine Scrub/Shrub Wetland
Saline Marsh (High Marsh) **Saline Marsh (Low Marsh)** **Phragmites Dominate Coastal Wetlands** **Disturbed Tidal Wetlands**	Estuarine Emergent Wetland
*** Designates assignment based on expert judgement and data-driven GIS overlay analysis.**	

Currently, NGHGI does not estimate GHG emissions/removals for inland wetlands due to insufficient data to develop emissions parameters, although this is an active area of investigation. Preliminary analysis of conversion dynamics revealed a loss of over 20,000 acres of inland wetlands and water in New Jersey between 1995 and 2020, indicating the potential for substantive changes in net emissions. A literature review (Cui et al. 2024; IPCC 2014) indicates that pathways for GHG emissions/removals are largely similar to those of coastal wetlands, though different emissions factors are applied. In particular, temperature may drive methane production to be substantially higher in inland palustrine wetlands compared to their estuarine coastal counterparts. Conversion of wetlands to non-wetland land cover types typically reduces soil carbon accumulations rates and may disturb soil carbon. Drained wetland soils continue to emit carbon dioxide for 20 years after wetland conversion. On mineral soils, and on organic soils emissions continue until stock is exhausted or soils become wet. Methane production declines once soils are drained, reducing emissions from that point forward. The New Jersey inventory will apply and expand the methodology utilized by the NGHGI and estimate emissions from coastal and inland wetlands.

Soils

Soil Carbon dynamics in wetlands are also dependent on soil taxonomic order, therefore, all wetlands were disaggregated based on mineral or organic soils. Data on taxonomic order was taken from the USDA SSURGO dataset (retrieved May 2025). See cross-cutting section for the steps to incorporating soil data into relevant land categories.

Elevation

Tidal extent maps were created by The Nature Conservancy (TNC) by interpolating data from the NOAA VDatum, as part of the development of TNC Restoration Explorer App (TNC 2015[11], Lathrop 2015). The high tide line was used to delineate between coastal and inland sub-categories of New Jersey wetlands. The Bureau of GIS at NJDEP periodically updates the state coastal inundation maps using NOAA tidal datums and LiDAR-derived digital elevation maps which should be used in future inventory cycles to reflect the changing coastline in delineation of coastal and inland wetlands.

Salinity

New Jersey DEP's LULC data indicate that the State gained over 3,000 acres of coastal wetlands between 1995 and 2020. Rewetting or restoring wetlands results in the return of wetland-level soil carbon accumulation and methane emissions. While estuarine areas generally have low methane emissions, palustrine wetlands may emit multiple orders of magnitude more methane than the previous ecosystem.

CCAP data recognizes two salinity categories for wetlands: estuarine (> 0.5 ppt) and palustrine (≤ 0.5 ppt). This dataset does not differentiate between species within a wetland type. Because CH_4 emissions decline along a gradient of increasing salinity (Arias-Ortiz et al. 2024), further salinity differentiation was applied.

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[11] See here: https://coastalresilience.org/project/restoration-explorer.

Salinity maps were created by Rutgers University from data collected at sampling sites set by the National Water Quality Monitoring Council, as part of the development of The Nature Conservancy (TNC) Restoration Explorer App (TNC 2015[12]; Lathrop 2015). These maps provided salinity values in the range of 0 to 32.8 ppt at the 250 ft resolution for all wetland sub-classes used in the inventory. Weighted-average salinity was calculated for each wetland sub-class using total area from 2012 NJ LULC dataset and used consistently across the entire time series. For types of subclasses for which no salinity is estimated due to lack of salinity data points, the default assumption was to assign "Fresh" classes (i.e., entering "0" (zero) as data in the calculator).

To prepare activity data for the GHG emission and removal estimates from wetlands, NJ LULC dataset was spatially joined with three environmental datasets – soil, elevation and salinity enabling classification of wetlands as coastal or inland through proximity-based analysis and providing a methane emission factor and carbon accumulation rate to facilitate distinction between mineral and organic soil types. The spatial analysis to join these dataset were conducted as part of cross-cutting data preparation and described in detail in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning).

While high-resolution spatial salinity data is useful in further stratifying wetland classes and assigning emission parameters, calculating salinity for wetland classes for years other than 2015 (when salinity data was collected) increases uncertainty as boundaries of wetland classes change.

The steps to download and prepare activity data for wetland extent by sub-class, for entry into the NJ Wetland Calculators, are outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning). Activity data entry steps are described in the NJ NWL Calculator Manual (Section: Wetlands Calculator).

Wetlands remaining wetlands

To estimate carbon stocks in relevant carbon pools, we will apply the activity data framework described in section on cross-cutting data in which activities pertaining to wetlands include wetlands remaining vegetated wetlands (WRW), conversion between vegetated or unvegetated (also WRW), or land converted to wetland (LCW) from a non-wetland land use type. This encompasses all types of management resulting in maintenance, conservation, restoration, or other gains of wetlands. More detailed wetland management activities are not specified, though transitions of one NJ LULC sub-class to another can be considered their own activity for each unique combination of starting and ending NJ LULC sub-classes. Since there are numerous NJ LULC sub-classes in the state maps that exist across a salinity range, it is possible to identify hundreds of unique transitions involving the conversion of one NJ LULC sub-class to another. These will be binned into groups of similar transitions for the purpose of assigning emissions factors. These include:

1. Vegetated wetlands remaining vegetated wetlands
2. Vegetated wetlands converted to open water

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[12] See here: https://rutgers.maps.arcgis.com/apps/mapviewer/index.html?layers=e932ab1607a34278b304cd8a293d8382

3. Open water converted to vegetated wetlands

The same approach will be applied to both coastal and inland wetlands in New Jersey.

Land converted to wetlands

Land converted to wetlands is further disaggregated by land category from which it was converted to enable of estimating of C fluxes and non-CO_2 emissions, as appropriate. All data entered in the New Jersey Land Converted to Wetlands Calculator and calculator must be in acres as the area units. Acres is also the unit from the source dataset. Therefore, no conversions are necessary. For step by step instructions see the NJ NWL Calculator Manual (Section: Land converted to Wetlands Calculator/Land Area 1-6).

Wetlands converted to other land use categories are not included in the wetlands portion of the inventory and are instead quantified under the activity appropriate to their new respective terrestrial NJ LULC sub-class. For example, emissions associated with wetland conversion to impervious development (e.g., draining standing water, removing biomass, and excavating soils) would be included under the activities of the Settlement section of the inventory.

Aquaculture

The primary aquaculture production in the State of New Jersey is for clams and oysters. It is estimated that fin fish production constitutes less then 10% of aquaculture production in the state consisting of a koi farm and several trout hatcheries (expert opinion – Michael P. Acquafredda, staff at the New Jersey Sea Grant Consortium/Haskin Shellfish Research Laboratory, Rutgers University). The clams and oysters are raised on subtidal and intertidal areas, respectively with the majority of production occurring on state land leased to individual farmers. As of 2025, the total area of leases is approximately 34,000 acres, though only a fraction of that is used for production. According to IPCC guidelines, aquaculture can contribute to N_2O emissions when N is added to fish cages as feedstock. Shellfish production, which constitutes the majority of aquaculture activities in New Jersey, doesn't utilize additional feedstock. Therefore, aquaculture emissions are expected to be very low and not estimated in the inventory.

New Jersey DEP, Bureau of Marine and Water Monitoring and Bureau of Shellfish and Marine Habitat collect data on production, in particular for shellfish, and oversee compliance with rules and regulations relevant to aquaculture activities. Rutgers University Haskin Shellfish Research Laboratory also conducts research and monitoring. In the event that aquaculture profile and methods changes in the future, these entities should be engaged to obtain data on production (kg of fish produced annually) and production practices. New Jersey has implemented a new rule that will require shellfish farmers to report production numbers to the state starting in 2025, which may support data collection efforts if it becomes relevant for the inventory (use of feedstocks in production).

Emission parameters

Wetlands remaining wetlands

Emission factors for New Jersey wetlands have been primarily derived from coastal studies (Holmquist et al. 2018) due to the historical focus on blue carbon ecosystems. These factors can be appropriately applied to inland wetlands with specific adjustments because the fundamental biogeochemical processes governing carbon sequestration remain similar - both involve anaerobic conditions that slow organic matter decomposition, leading to carbon accumulation. The critical difference lies in methane emissions, with freshwater inland wetlands typically exhibiting higher methane flux due to the absence of sulfate, which inhibits methanogenesis in saline environments (Poffenbarger et al. 2011). This inventory methodology accounts for these differences by incorporating salinity stratification in the emission factors. Recent research by Arias-Ortiz et al. (2024) demonstrates similar carbon accumulation patterns across the coastal-inland gradient when controlling for vegetation type and elevation, with the primary divergence being in methane production rates. Synthesis of global literature by Sapkota et al. (2025) focusing specifically on freshwater forested wetlands, showed that C stocks vary by ecological and vegetation characteristics. As palustrine forested wetlands are the majority of New Jersey wetland classes, differentiated carbon stocks for palustrine forested wetlands were applied. By maintaining the carbon accounting structure while adjusting methane emission factors based on salinity, we create a comprehensive framework applicable to New Jersey's diverse wetland systems. The emission parameters for the soil carbon and methane emission rates are provided in Table 40 and Table 41, respectively. See NJ NWL Calculator Manual (Section: Wetlands remaining Wetlands Calculator/Emission Factors) for guidance on entering the parameters into the NJ Wetlands Remaining Wetlands Calculator.

Table 40. Soil C stock and C accumulation rates for estimating soil C fluxes in wetlands. All values taken directly from publications in the Reference column

Parameter type	Transition Category	Elevation	CCAP class (converted from)	Salinity range	Value (tonne C hectare^{-1})	Reference	Converted Value (tonne C acre^{-1})
Soil C stock [a]	Vegetated to open water	Coastal wetlands	All, except palustrine forest	All	269.66	Holmquist (2018)	109.13
Soil C stock [a]	Vegetated to open water	Coastal wetlands	Palustrine forest	Fresh (≤ 0.5 psu)	341.6 ± 98.4	Sapkota (2025)	138.24
Soil C stock [b]	Vegetated to open water	Inland wetlands	All, except palustrine forest	All	75.0	Calculated from SSURGO/Table 8	30.35
Soil C stock [a]	Vegetated to open water	Inland wetlands	Palustrine forest	Fresh (≤ 0.5 psu)	229.3 ± 120.4	Sapkota (2025)	92.79
Parameter type	**Transition Category**	**Elevation**	**CCAP class (converted to)**	**Salinity range**	**Value (tonne C hectare^{-1} year^{-1})**	**Reference**	**Converted Value (tonne C acre^{-1} year^{-1})**
Soil C accumulation rate	Vegetated Remaining Vegetated Open water to Vegetated	All	All	Fresh (≤ 0.5 psu)	1.544 ± 0.45	NGHGI (2024)	0.625
Soil C accumulation rate	Vegetated Remaining Vegetated Open water to Vegetated	All	All	Oligohaline/Brackish marsh (0.5 - 5.0 psu)	1.039 ± 0.18	NGHGI (2024)	0.42
Soil C accumulation rate	Vegetated Remaining Vegetated Open water to Vegetated	All	All	Mesohaline/ Brackish marsh (5.0 - 18 psu)	1.039 ± 0.18	NGHGI (2024)	0.42
Soil C accumulation rate	Vegetated Remaining Vegetated Open water to Vegetated	All	All	Polyhaline/Salt marsh (18 – 35 psu)	1.039 ± 0.18	NGHGI (2024)	0.42

[a] SOC at 1 m soil depth for organic and mineral soils
[b] calculated for 1 m soil depth for organic and mineral soils for inland wetlands from SSURGO data
For values from Sapkota (2025) - median (± median absolute deviation). SOC at 1m depth
For values from the National GHG Inventory (NGHGI, US EPA 2024), ± value represents the 95% confidence interval

Methane emissions are driven by salinity, temperature, and elevation. Emission parameters were selected from a study by Arias-Ortiz (2024) that represents New Jersey's annual average temperature (approximately 12 – 13 °C) where temperature-based emission factors were available. Furthermore, where emission factors were differentiated by elevation, for fresh and oligohaline salinity ranges, high elevation parameter was applied to forested and scrub/shrub dominated systems and low-mid elevation parameter was applied to wetlands with emergent vegetation to reflect expected relationship between elevation and vegetation type.

Table 41. Methane emission factors, applicable to all CCAP wetland classes where transition occurs to vegetated wetlands. All values taken directly from Arias-Ortiz publication.

Parameter type	CCAP class	Salinity range	Value (tonne CH_4 hectare^{-1} year^{-1})	Reference	Converted Value (tonne CH_4 acre^{-1} year^{-1})
Methane $EF_{F\text{-}FSS}$	Palustrine forest, scrub/shrub	Fresh (≤ 0.5 psu)	0.038 (0.027)	Arias-Ortiz (2024)	0.0153781
Methane $EF_{F\text{-}EM}$	Palustrine emergent	Fresh (≤ 0.5 psu)	0.15 (0.105)	Arias-Ortiz (2024)	0.0607028
Methane $EF_{O\text{-}FSS}$	Estuarine/palustrine forest, scrub/shrub	Oligohaline (0.5 – 5.0 psu)	0.038 (0.027)	Arias-Ortiz (2024)	0.0153781
Methane $EF_{O\text{-}EM}$	Estuarine/palustrine emergent	Oligohaline (0.5 – 5.0 psu)	0.15 (0.105)	Arias-Ortiz (2024)	0.0607028
Methane EF_M	All	Mesohaline (5.0 - 18.0 psu)	0.034 (0.036)	Arias-Ortiz (2024)	0.0137593
Methane EF_P	All	Polyhaline (> 18 psu)	0.012 (0.029)	Arias-Ortiz (2024)	0.0048562
Note: Even though Estuarine Emergent Wetlands are expected to not be fresh waster, existing salinity datasets contain values <0.5 psu for some Estuarine Emergent Wetland classes. Therefore, emission factors for fresh Palustrine Emergent Wetlands are applied in the calculator (0.0607028).					

The emission parameters for non-forest biomass C will be assigned based on CCAP categorization (a). The emissions factors for New Jersey wetlands are taken from the NGHGI (Table 43) and were based on averages for the *Warm Temperate* climate zone within the U.S., representing an improvement over national Tier 2 estimates but lacking the specificity needed for Tier 3 state-level estimates. In the absence of data from either of these sources, we used Tier 1 IPCC defaults (IPCC 2014).

For palustrine forested wetlands, biomass carbon densities were determined using New Jersey FIA data following a similar process used for forest lands category (see Table 10). The data was queried with row variable set to physiographic class and values for swamps/bogs, small drains, and other hydric sites were used. The average value was derived by summing the numerator and the denominator, for the three classes, and taking the ratio as shown in Table 42.

*Table 42. New Jersey forested wetlands **biomass C density** derived from FIA data samples collected on sites with wet soil conditions, physiographic classes included are swamp/bogs, small drains, and other hydric soil types. Total Carbon and area values were determined by summing across for all plots to derive the C density.*

C pool	Forest Physiographic class	Plot count	Carbon (tonne C)	Area (acre)	C density (tonne C acre^{-1})
			A	B	C = A / B
Aboveground biomass (AGB)	Swamps/bogs	40	2,544,504	111,180	
	Small drains	5	369,639	9,282	
	Other hydric	6	627,654	18,894	
	Total	**51**	**3,541,797**	**139,356**	**25.42 ± 8.22**
Belowground biomass (BGB)	Swamps/bogs	40	483,170	111,180	
	Small drains	5	66,765	9,282	
	Other hydric	6	108,810	18,894	
	Total	**51**	**658,744**	**139,356**	**4.72 ± 1.87**
Deadwood	Swamps/bogs	40	67,870	111,180	
	Small drains	5	1,830	9,282	
	Other hydric	6	133,363	18,894	
	Total	**51**	909,798	**139,356**	**6.53 ± 1.78**
Litter	Swamps/bogs	40	745,649	111,180	
	Small drains	5	62,821	9,282	
	Other hydric	6	127,525	18,894	
	Total	**51**	935,994	**139,356**	**6.72 ± 0.48**
± value represents the 95% confidence interval					

Table 43. New Jersey wetlands biomass C and DOM C emissions factors from the NGHGI (US EPA 2024) for Wetlands Remaining Wetlands (includes conversion between vegetated and unvegetated wetlands). Note that while parameters are the same for the different transitions, the resulting C flux is calculated differently.

Vegetated Wetland remaining Vegetated Wetland							
Wetland Category	**AGB C density (tonne C ha^{-1})**	**AGB C density (tonne C acre^{-1})**	**BGB C density (tonne C ha^{-1})**	**BGB C density (tonne C acre^{-1})**	**DOM C density (tonne C ha^{-1})**	**DOM C density (tonne C acre^{-1})**	**Reference**
Palustrine Forested Wetland		See Table 42		See Table 42		See Table 42	NJ FIA data
Palustrine Scrub/Shrub Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Palustrine Emergent Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Estuarine Emergent Wetland	3.1 ± 0.26	1.255	6.54*	2.647	0	0	NGHGI (2024)
Vegetated to Water/Unvegetated Wetland							
Wetland Category	**AGB C density (tonne C ha^{-1})**	**AGB C density (tonne C acre^{-1})**	**BGB C density (tonne C ha^{-1})**	**BGB C density (tonne C acre^{-1})**	**DOM C density (tonne C ha^{-1})**	**DOM C density (tonne C acre^{-1})**	**Reference**
Palustrine Forested Wetland		See Table 42		See Table 42		See Table 42	NJ FIA data
Palustrine Scrub/Shrub Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Palustrine Emergent Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Estuarine Emergent Wetland	3.1 ± 0.26	1.255	6.54*	2.647	0	0	NGHGI (2024)
Water/Unvegetated to Vegetated Wetland							
Wetland Category	**AGB C density (tonne C ha^{-1})**	**AGB C density (tonne C acre^{-1})**	**BGB C density (tonne C ha^{-1})**	**BGB C density (tonne C acre^{-1})**	**DOM C density (tonne C ha^{-1})**	**DOM C density (tonne C acre^{-1})**	**Reference**
Palustrine Forested Wetland		See Table 42		See Table 42		See Table 42	NJ FIA data
Palustrine Scrub/Shrub Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Palustrine Emergent Wetland	3.17 ± 0.26	1.283	3.64*	1.473	0	0	NGHGI (2024)
Estuarine Emergent Wetland	3.1 ± 0.26	1.255	6.54*	2.647	0	0	NGHGI (2024)

* BGB values estimated using default Root-to-Shoot ratios provided in the 2013 Supplement to the 2006 IPCC Guidelines (Ch. 4, Table 4.9) for temperate freshwater tidal marshes (1.15, 95% CI of the geometric mean (1.12, 1.18)) for palustrine wetlands, and temperate (2.11, 95% CI of the geometric mean (2.07, 2.15)) for estuarine wetlands
AGB = aboveground biomass. BGB = belowground biomass. DOM = dead organic matter (sum of Deadwood and Litter pools)

Land converted to wetlands

Emission parameters for the following emissions and removals are utilized in the calculations:

1. CH_4 emissions on non-wetland land converted to vegetated wetlands (calculated the same way as for Wetlands Remaining Wetlands)
2. Carbon stock changes (biomass, dead organic matter) on non-wetland land converted to coastal and inland wetlands.
3. Soil carbon flux on land (all categories) converted to vegetated wetlands, for coastal and inland wetlands on mineral and organic soils.

The biomass C densities for New Jersey land converted to wetlands (both coastal and inland) are taken from the NGHGI (Table 44) and were based on averages for the *Warm Temperate* climate zone within the U.S., representing an improvement over national Tier 2 estimates but lacking the specificity needed for Tier 3 state-level estimates. This source was predominantly used for LCW activities, which involve loss of biomass from the pre-transition land category, or when transitions between wetland types involved losses of biomass. For pre-transition biomass C density, for forest lands and grassland, New Jersey specific parameters are used (based on FIA data). In the absence of data from either of these sources, for cropland we used Tier 1 IPCC defaults (IPCC 2019) or literature as noted in Table 44. See NJ NWL Calculator Manual (Section: Land converted to Wetlands Calculator/Emission Factors) for guidance on entering the parameters into the NJ Land Converted to Wetlands Calculator.

Table 44. Carbon density parameters for Land Converted to Wetlands. References provided in each land category section.

Converted from	Pre-transition biomass C density (tonne C acre^{-1})	Converted to	Post-transition C density (tonne C acre^{-1})
Settlement	Open space – AGB: 11.8/BGB: 2.0 Low intensity development – AGB: 27.1/BGB: 4.4 Medium intensity development – AGB: 20.9/BGB: 3.7 High intensity development – AGB: 30.8/BGB: 4.2	Palustrine Forested Wetland	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25
		Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47
		Palustrine Emergent Wetland	Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47
		Estuarine Emergent Wetland	Estuarine Emergent Wetland – AGB:1.25/BGB:2.650
		Water (Unvegetated wetland)	0
Cropland	Orchards - 2.58 Berries - 4.64 Annual crops – 1.9	Palustrine Forested Wetland	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25
		Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47
		Palustrine Emergent Wetland	Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47

Converted from	Pre-transition biomass C density (tonne C acre^{-1})	Converted to	Post-transition C density (tonne C acre^{-1})
		Estuarine Emergent Wetland	Estuarine Emergent Wetland – AGB:1.25/BGB:2.650
		Water (Unvegetated wetland)	0
Grassland	AGB: 0.714 BGB: 0.079	Palustrine Forested Wetland	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25
		Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47
		Palustrine Emergent Wetland	Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47
		Estuarine Emergent Wetland	Estuarine Emergent Wetland – AGB:1.25/BGB:2.650
		Water (Unvegetated wetland)	0
Forest	See Table 14, Table 15, and Table 16 for C stocks for each forest sub-category	Palustrine Forested Wetland	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25
		Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47
		Palustrine Emergent Wetland	Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47
		Estuarine Emergent Wetland	Estuarine Emergent Wetland – AGB:1.25/BGB:2.650
		Water (Unvegetated wetland)	0
Other	0	Palustrine Forested Wetland	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25
		Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47
		Palustrine Emergent Wetland	Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47
		Estuarine Emergent Wetland	Estuarine Emergent Wetland – AGB:1.25/BGB:2.650
		Water (Unvegetated wetland)	0

To determine soil C fluxes, the same carbon stock and accumulation rate values are utilized as for wetlands remaining wetlands (see Table 40). When a dry land category is converted to a vegetated wetland, carbon is removed from atmosphere into soil according to the accumulation rate per salinity class. It is assumed to be equal for both coastal and inland wetlands and applicable to both organic and minearal soils. When a dry land category is converted to an unvegetated wetland or open water, is assumed that carbon is emitted to the atmosphere in the year of transtion. For coastal wetlands, for both mineral and organic soils, C flux is equal to the C stock lost according to C stock values in Table 40. For inland wetlands, for both mineral and organic soils, the C stock is determined from SSURGO data at 30 cm depth.

The parameters identified in tables above are also found in the NWL Wetland WRW and LCW calculators in the units they are provided in this section. The NWL calculators automatically convert activity data to the appropriate units of the relevant emission factors, e.g., hectares to acres, kg to tonne, as appropriate.

Activity data and emission parameters for New Jersey wetland sub-classes remain disaggregated for analysis in the calculators, which allows entry of refined emission factors and parameters should new studies allow derivation of refined emission factors.

Calculations

Carbon fluxes and methane emissions are calculated automatically by the New Jersey Wetland NWL calculator when activity data and emission parameters are entered by the user (see NJ NWL Calculator Manual, Section: Wetlands Remaining Wetlands Calculator/Emission estimates and Land Converted to Wetlands Calculator/Emission estimates). Net GHG emissions and removals are calculated annually for each land category using the following approaches, consistent with the IPCC 2013 Wetlands Supplement, are used:

- Stock-Difference Approach: Used for biomass and dead organic matter carbon pools, where change is estimated as the difference in stocks at two points in time.
- Gain-Loss Approach: Used for soil carbon, where change is estimated as the net of gains and losses over the period using an emission factor.

The IPCC 2006 Guidelines and 2013 Wetlands Supplement specify that when land transitions from one category to another (e.g., grassland to wetland), the area is classified as "land converted to [new category]" for a default transition period of 20 years. During this period, emissions and removals are attributed to the conversion process, reflecting the time required for carbon pools (especially soil carbon) to adjust to a new equilibrium. As described in section on cross-cutting data preparation, New Jersey does not currently track data this way, therefore, the transition period equals the number of years since the previous dataset release.

The following assumptions are applied in the calculations:

1. For transitions from vegetated wetlands to unvegetated wetlands (e.g., open water or unvegetated), all biomass carbon and soil carbon is assumed lost in the year of transition, following IPCC (2014) guidance that biomass changes are immediate.
2. For wetlands with emergent vegetation, DOM flux is assumed to be zero (DOM flux = 0), as the formation and decomposition of dead organic matter reach equilibrium in undisturbed wetland systems (Holmquist et al. 2018).
3. Soil carbon accumulation occurs at rates specific to each wetland type, with these

rates determined by vegetation structure, elevation, and salinity. For all ecosystems, it is assumed that soil C accumulation begins in the same year that transition occurs. The soil C accumulation rate for each ecosystem is assumed to equal that of a mature wetland due to lack of data in restoration sites. Soil C stock losses are assumed to occur in the year of transition when transition to unvegetated wetland/open water occurs.

4. For land converted to wetlands, it is assumed that pre-conversion biomass C is lost in the year of transition

The carbon fluxes and methane emissions are estimated by the New Jersey Wetlands Calculators according to the formulas listed below. Note that emission factors in section above are provided in units in which they were derived and published. All activity data (entered in acres) are converted by the calculator to the proper EF units, as needed. The same formulas are used for coastal and inland wetlands.

Wetlands remaining wetlands: Vegetated Wetland Remaining Vegetated Wetland (VRV)

Biomass C flux from growth

Annual biomass C flux is calculated for each VRV wetland class and summed together to estimate total annual flux.

Equation 26. VRV Biomass Carbon Flux

$$Biomass\ and\ DOM\ C\ flux\ (tonne\ C\ year^{-1}) = (-1) \times \left((VRV\ wetland\ area\ (acres)_t - VRV\ wetland\ area\ (acres)_{t-1}) \times\ (AGB + BGB + DOM\ C\ density)\right)$$

Where t is the current year of the inventory, t-1 is the previous year of the inventory

C is converted to CO2 by multiplying by (44/12).

Soil C flux

Annual soil C flux is calculated for each VRV wetland class and summed together to estimate total annual flux.

Equation 27. VRV Soil Carbon Flux

$$Soil\ C\ flux\ (tonne\ C\ year^{-1}) = VRV\ wetland\ area\ (acres) \times\ soil\ C\ accumulation$$

C is converted to CO2 by multiplying by (44/12).

Soil CH_4 emissions

Annual CH4 emissions are calculated for each VRV wetland class and summed together to estimate total annual emissions.

Equation 28. Soil CH4 emissions

$$Soil\ CH_4\ emissions\ (tonne\ CH_4\ year^{-1}) = VRV\ wetland\ area\ (acres) \times \text{Methane EF}$$

Use the appropriate methane EF per salinity range. Applies to all wetlands remaining wetlands.

Wetlands remaining wetlands: Vegetated to Water/Unvegetated Wetland

Biomass C flux from loss of biomass (emissions)

C stock changes are calculated for each wetland class and summed together to estimate total C stock change due to conversion. All biomass is assumed to be lost in the year of transition.

Equation 29. Biomass Carbon flux for vegetated wetlands converting to water/unvegetated wetlands

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = (Vegetated\ converted\ to\ Water/Unvegetated\ wetland\ area\ (acres)\ \times\ (AGB\ +\ BGB\ C\ +\ DOM\ C\ density)$$

C is converted to CO2 by multiplying by (44/12).

Soil C flux (emission)

Annual soil C flux is calculated for each wetland class and summed together to estimate total annual flux.

Equation 30. Soil carbon flux for vegetated wetlands converting to water/unvegetated wetlands

$$Soil\ C\ flux\ (tonne\ C\ year^{-1}) = Vegetated\ converted\ to\ Water/Unvegetated\ wetland\ area\ (acres) \times\ soil\ C\ density$$

C is converted to CO2 by multiplying by (44/12).

Wetlands remaining wetlands: Water/Unvegetated to Vegetated Wetland

Biomass C flux from growth (removal)

C stock changes are calculated for each wetland class and summed together to estimate total C stock change due to conversion. Biomass stocks are assumed to be gained in the year of transition.

Equation 31. Biomass Carbon flux for water/unvegetated wetlands converting to vegetated wetlands

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = (-1) \times [Water/Unvegetated\ converted\ to\ vegetated\ wetland\ area\ (acres) \times\ (AGB + BGB + DOM\ C\ density)]$$

C is converted to CO2 by multiplying by (44/12).

Soil C flux (removal)

Annual soil C flux is calculated for each wetland class and summed together to estimate total annual flux.

Equation 32

$$Soil\ C\ flux\ (tonne\ C\ year^{-1}) = (-1) \times Water/Unvegetated\ converted\ to\ vegetated\ wetland\ area\ (acres) \times \text{soil C accumulation rate}$$

C is converted to CO2 by multiplying by (44/12).

Land Converted to Wetlands

Biomass Carbon Stock Change (conversion)

For conversion, all pre-transition biomass is assumed to be lost in the year of transition.

Equation 33. LCW Biomass Carbon Stock Change from conversion to wetlands

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = Land\ converted\ to\ wetland\ area\ (acres) \times \text{Biomass}\ C\ density_{Pre-transition}$$

Biomass Carbon Gain

C stock gains are calculated for each wetland type and summed together to estimate total C stock change in biomass on land converted to wetlands.

Equation 34. LCW Biomass Carbon gain from conversion

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = (-1) \times Land\ converted\ to\ wetland\ area\ (acres) \times (\text{AGB} + \text{BGB} + \text{DOM C density})$$

The total biomass carbon flux for land converted to wetlands is the sum of stock changes due to conversion and gains for new wetlands. C is converted to CO2 by multiplying by (44/12).

Soil C flux

Soil C flux is calculated for land converted to coastal and inland vegetated wetlands, on both mineral and organic soils.

Equation 35. Soil carbon flux for conversions to vegetated wetlands

$$Soil\ C\ flux\ (tonne\ C\ year^{-1}) = Land\ converted\ to\ wetland\ area\ (acres)\ \times (Soil\ C\ Accumulation\ rate)$$

C is converted to CO2 by multiplying by (44/12).

Equation 36. Soil carbon flux for conversions to water/unvegetated wetlands

$$Soil\ C\ flux\ (tonne\ C\ year^{-1}) = Land\ converted\ to\ wetland\ area\ (acres)\ \times (Soil\ C\ \ stock)$$

NOTE: Soil C stock is used because all the C is lost in the year of transition

Soil CH_4

Equation 37. Soil CH4 emissions for land converted to wetlands

$$Soil\ CH_4\ (tonne\ CH_4\ year^{-1}) = Land\ converted\ to\ \ wetland\ area\ (acres)\ \times EF_{CH4}$$

Emissions are provided by wetland sub-class, for wetlands remaining wetlands and land converted to wetlands, by carbon pool as applicable. The summary tab in the Wetlands Remaining Wetlands and Land Converted to Wetlands Calculator provides total emission by main categories.

Uncertainty

Underlying uncertainties in the estimates of soil and biomass carbon stock changes and CH_4 emissions in coastal wetlands include uncertainties associated with values for soil carbon stocks, biomass carbon stocks and CH_4 emissions factors. To assign emission factors, mapping of NJLULC categories to CCAP classes was implemented. Some existing NJ wetland categories exhibited below 50% alignment with mapped CCAP classes adding to uncertainty in estimating carbon stock changes and CH_4 emissions.

Furthermore, assumptions on temporal dynamics that underlie the methodological approaches applied lead to uncertainty. For example, losses of biomass or soil carbon stocks are assumed to occur in the year of transition, however, it may take decades to reach a new equilibrium.

Also, there are uncertainties linked to interpretation of remote sensing data – NJ LULC has many wetland sub-categories, but lacks systematic information regarding associated vegetation, function, and transitions. On the other hand, there is no sub-category that captures ghost forests in New Jersey, which could help improve accuracy in estimates of biomass carbon fluxes. Uncertainty is also linked to salinity activity data, which is currently static and assumed to remain constant over the entire time series.

For inland wetlands, parameters for soil and biomass carbon stock data for all subcategories are not available and thus assumptions were applied using expert judgment about the most appropriate assignment of a carbon stock to inland sub-categories. Currently, inland wetland sub-classes are included in the inventory, but there is insufficient local data to develop specific emission factors for each sub-category. Most emission factors are adapted from coastal wetland studies and adjusted for salinity and elevation or default IPCC emission factors are applied. However, this approach does not capture the full range of inland wetland types and management practices.

Future improvements

To improve the accuracy of wetland GHG estimates in New Jersey, the main technical focus for future improvements should be on building better data and research for inland wetlands, as this is currently the biggest limitation.

To keep the process simple and practical for future work:

- Maintain the current level of detail wetland sub-categories in the inventory, so that new emission factors can be added as research becomes available.
- As new field studies or literature on inland wetland GHG fluxes (especially methane) become available, update emission factors for the relevant sub-classes. This can be done without changing the existing GIS workflow or data structure.

Furthermore, land classification of forested wetlands needs to be addressed to improve identification of forested when data collection occurs following dry years. Preliminary emission calculations showed big jumps in emissions and removals in the years of new land use land cover datasets. In particular, these jumps seem to coincide with changes in area of deciduous forests suggesting misclassification between forested wetlands and deciduous forests.

In addition, it is recommended to utilized updated NJDEP Bureau of GIS generated tidal extent maps in delineating coastal and inland wetlands in the future inventory cycles to better reflect New Jersey changing coastal zones.

SETTLEMENTS

The *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) provides procedures for quantification of GHG emissions and removals from Settlements. This methodology is accepted for estimating GHG emissions/removals in the Settlements category in the NGHGI (EPA 2024). The New Jersey adapts NGHGH and estimates the following categories for the Settlements category:

- Carbon fluxes in urban trees (includes trees on land converted to Settlements)
- Emissions from drained organic soils (CO_2, CH_4, and N_2O)
- N_2O emissions from soils (direct and indirect) from fertilizer application
- Carbon fluxes in Land Converted to Settlements (by carbon pool)

Changes in yard trimmings (i.e., grass, leaves, and branches) and food scrap C stock that are landfilled are estimated and provided for information only due to data limitations.

An IPCC Tier 1 method is used to estimate soil organic C stock changes for organic soils in settlements remaining settlements (IPCC 2013 Wetland Supplement). Organic soils in settlements remaining settlements are assumed to be losing C at a rate similar to croplands due to deep drainage (Ogle et al. 2003), therefore emission factors for croplands were used. All settlements occurring on organic soil are assumed to be drained for the purposes of approximating greenhouse gas emissions. The changes in C stock on mineral soils are not estimated due to data limitations.

Dominant factors affecting carbon flux trends for settlement trees are changes in the amount of settlement area (increasing sequestration due to more land and trees) and net changes in tree cover (e.g., tree losses versus tree gains through planting and natural regeneration). To quantify the carbon stored in settlement trees, the methodology used by NGHGI requires analysis per unit area of tree cover, rather than per unit of total land area (as is done for forest lands).

In Settlements, N_2O emissions from soils occur due to the application of synthetic N fertilizers or biosolids to soils to lawns, golf courses, and other landscaping and from drained organic soils. Emissions are direct and indirect (due to volatilization and leaching). Because the contribution of emissions from this category is expected to be low, a Tier 1 approach with IPCC default emission factors was used. Emission estimates were based on the amount of N in the fertilizer applied to soil and the area of drained lands.

When wastes of biogenic origin (such as yard trimmings and food scraps) are landfilled and do not completely decompose, the carbon that remains is effectively removed from the carbon cycle. Evidence indicates that yard trimmings and food scraps do not completely decompose in landfills (De la Cruz and Barlaz 2010), and thus the stock of carbon in landfills can increase, with the net effect being the removal of carbon from the atmosphere. The NGHGI estimates the net carbon flux resulting from landfilled yard trimmings and food scraps by determining the change in landfilled carbon stocks between inventory years and uses a country-specific methodology. The NGHGI approach deviates from recommendations in the IPCC Guidelines which are to report these as an additional HWP pool in SWDS or as a separate “Other” category in the land sector (IPCC, 2006).[13] Carbon stock estimates are calculated by determining the mass of landfilled carbon resulting from yard trimmings and food scraps discarded in a given year; adding the accumulated landfilled carbon from previous years; and subtracting the mass of carbon that was landfilled in previous years and has since decomposed and been emitted as CO_2 and CH_4.

Carbon stock changes in yard trimmings and food scraps are provided for information only. They are included under settlements remaining settlements because landfills are considered part of the managed land under settlements, and the reporting of these carbon stock changes that occur entirely within landfills fits most appropriately within the settlements remaining settlements section (NGHGI, US EPA 2024). The CH_4 emissions resulting from anaerobic decomposition of yard trimmings and food scraps in landfills are reported under the waste sector.

When land is converted to settlements, it can lead to losses of carbon to the atmosphere, particularly from conversions from forest land to settlements. New Jersey’s current GHG inventory includes a category called “Land Clearing,” which accounts for some of these losses. The proposed methodology will be improved in terms of completeness and account for changes in C stocks (biomass and soil) due to the conversion of other land use types to settlements. For forest land converted to settlements, the carbon stocks for biomass, litter, and deadwood will be calculated following the methodology outlined in the Forest Land section and assumed to be lost in the year when the land conversion occurred. Mineral soil C fluxes will be calculated using a Tier 1 approach by utilizing carbon factors from the 2019 Refinement to the 2006 IPCC Guidelines. Organic soil C losses will be estimated using the same method as for Settlements remaining Settlements.

Data flows for compiling emission and removal estimates for Settlements are shown in Figure 13.

[13] This discrepancy is documented in the Technical Expert Review Report of the National Inventory submission by the US in 2022.

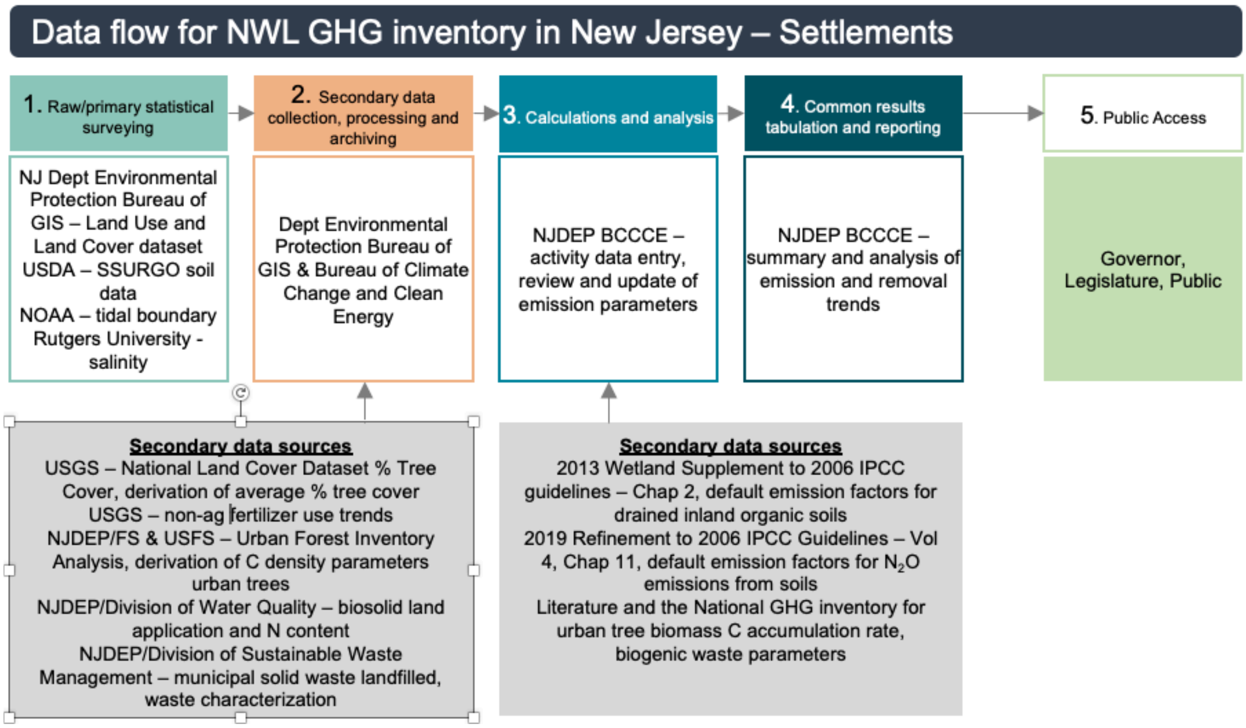

Figure 13. Data flow for NWL GHG inventory in New Jersey for the Settlement category

Activity data

Land area

The LULC classes designated as Settlements are listed in Table 45. The categories are also categorized according to their development density to match the National Land Cover Database (NLCD), which can be used to assign tree canopy values to estimate C sequestration in urban trees. The mapping of NJ LULC classes to NLCD development land classes is applied automatically in the calculations. See the NJ NWL Calculator Manual (Section: Settlements Calculator/Documentation) for configuring the mapping of NJ LULC settlement classes to NLCD classes within the NJ Settlements Calculator. Note that this documentation tab is included in all NJ NWL calculators and must be consistent across all calculators because it is used to assign emission factors for estimating emissions and removals for all existing settlement areas, lands that have been converted to settlements, as well as settlements that have been converted to other land categories. Once configured, the New Jersey Settlements Calculator will automatically assign each NJ LULC sub-class to the appropriate NLCD category based on the configuration within the calculators documentation tab.

Table 45. NJ LULC categories included in the Settlements category of the inventory and associated NLCD class mapping.

Code	Category	NLCD developed land classes
1110	Residential, high density or multiple dwelling	High intensity
1120	Residential, single unit, medium density	Medium intensity
1130	Residential, single unit, low density	Low intensity
1140	Residential, single unit	Low intensity
1150	Mixed residential	Medium intensity
1200	Commercial/services	High intensity
1211	Military installations	High intensity
1214	No longer military	Open space
1300	Industrial	High intensity
1400	Transportation/communication/utilities	High intensity
1410	Major roadway	High intensity
1411	Mixed transportation corridor overlap area	High intensity
1420	Railroads	High intensity
1440	Airport facilities	High intensity
1462	Upland rights-of-way developed	Medium intensity
1463	Upland rights-of-way undeveloped	Open space
1499	Stormwater basin	Open space
1500	Industrial and commercial complexes	High intensity
1600	Mixed urban or built-up land	Medium intensity
1700	Other urban or built-up land	Medium intensity
1710	Cemetery	Open space
1711	Cemetery on wetland	Open space
1800	Recreational land	Open space
1804	Athletic fields (schools)	Open space
1810	Stadium, Theaters, Cultural Centers, and Zoos	Open space
2400	Other agriculture	High intensity
7500	Transitional areas	Open space

For each year when an updated LULC dataset is available, the settlement area for each of the categories is prepared according to the steps outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning) and further disaggregated by settlement remaining settlement and land converted to settlement. All data entered in the New Jersey Settlements calculator must be in acres as the area units. Acres is also the unit from the source dataset. Therefore, no conversions are necessary. For step by step instructions see the NJ NWL Calculator Manual (Section: Settlements Calculator/Land Area 1, 3-7).

Stratification by soil type

Settlements are disaggregated by soil taxonomic order into mineral or organic soils. Soil organic carbon (SOC) fluxes occur due to changes in management and land conversion.

Furthermore, organic soils that have been drained emit CO_2, N_2O, and CH_4. Data on taxonomic order was taken from the USDA SSURGO dataset (retrieved May 2025). See the cross-cutting section for the steps on data preparation and processing. Area of settlements occurring on mineral and organic (assumed to be drained) soils is entered as activity data following instructions in the NJ NWL Calculator Manual (Section: Settlements Calculator/Land Area).

Settlement Trees and Tree Cover

To estimate net carbon sequestration by trees in settlement areas, based on the NGHGI methodology, total settlement area and percent tree cover (%TC) in settlement areas will be used. NGHGI utilizes the National Land Cover Dataset (NLCD) from USGS with adjustments to determine the percent tree cover using their open space, low, medium, and high-intensity development classification which applied to NJ LULC data as shown in Table 45. Tree cover in New Jersey was estimated by averaging tree cover values across the 4 categories of developed land classes in the NLCD for the years for which New Jersey land use land cover data is available. The NGHGI notes that NLCD is known to underestimate % tree cover in the analysis for the US (Nowak and Greenfield 2010) and applied a correction factor. However, in New Jersey, NLCD estimates of tree cover compared to estimates derived from photo-interpretation are comparable, therefore, the values in Table 46 were used as is. See NJ NWL Calculator Manual for instructions on deriving (Section: Activity data collection, processing, and cleaning/Third party datasets 4) and entering tree cover data (Section: Settlements Calculator/Emission Factors 11).

Table 46. Tree cover % for New Jersey based on based on NLCD tree cover data product

Year	Open space % TC	Low intensity %TC	Medium intensity %TC	High intensity %TC
1986	48.5	48.5	47.5	46
1995	49	48.5	48	46.5
2002	49	48	48	47
2007	49	48.5	48	47
2012	49	48	48	47
2015	48.5	48	48	47
2020	48.5	48	48	47

N_2O Emissions from soils

Nitrous oxide emissions occur due to application of synthetic N fertilizer and biosolids. Synthetic N fertilizer applications to settlement soils is estimated using data compiled by the USGS (Brakebill, J.W. and Gronberg, J.M., 2017; Falcone, J.A., 2021). The USGS report (Brakebill, 2017) provides state-level fertilizer application data based on sales records from 1987 to 2012 for each year disaggregated by farm and non-farm use. Data for 2017 is also available in subsequent report by Falcone (2021). In New Jersey, it can be assumed that all non-farm use is applied in settlements (none is applied in Forest Land). For years 2013-2016, data is interpolated. For subsequent years where data is not available, a historic average based on the last 10 years of available data. Data shown in Table 47. See NJ NWL Calculator Manual for instructions on processing (Section: Activity data collection, processing and cleaning/Third-party datasets 3) and entering activity data on fertilizer applied (Section: Settlements Calculator/Land Area 8).

Table 47. Nitrogen in synthetic N fertilizer applied to non-farms in New Jersey (kg N) (Reference: Brakebill and Gronberg 2017, Falcone 2021).

Year	kg N	Year	kg N
1987	2,231,393	2006	13,701,246
1988	7,723,327	2007	8,885,046
1989	7,803,156	2008	14,474,236
1990	7,626,537	2009	9,042,661
1991	7,055,363	2010	7,471,928
1992	7,049,777	2011	8,154,112
1993	9,869,111	2012	7,195,562
1994	9,844,347	2013	**7,886,380**
1995	8,953,136	2014	**8,577,198**
1996	11,892,480	2015	**9,268,017**
1997	8,254,153	2016	**9,958,835**
1998	11,739,805	2017	10,649,653
1999	15,935,573	2018	**9,267,858**
2000	13,036,725	2019	**9,267,858**
2001	13,342,775	2020	**9,267,858**
2002	9,706,635	2021	**9,267,858**
2003	8,832,574	2022	**9,267,858**
2004	10,865,854	2023	**9,267,858**
2005	10,419,245	2024	**9,267,858**
Values for years 2013-2016 are extrapolated (bold), values for 2018 to present are based on the average value for years 2008-2017 (bold).			

The amount of sludge produced and collected for land application in New Jersey was obtained from NJDEP, Division of Water Quality, Residuals, Sewage Sludge, and Biosolids program. The annual New Jersey Sludge Management Methods Reports[14] provide the weight of Class A (pellets/compost) sludge and Class B (liquid) sludge reported in dry metric tons per year for 2003-2023. Residuals from domestic sewage sludge production were used. The management modes of Class A and Class B residuals are as follows:

- CLASS A BENEFICIAL USE: Generator's sewage sludge is processed in New Jersey by a system designed to prepare Exceptional Quality sewage sludge for beneficial use as a fertilizer or other soil amendment. The process must meet specific pathogen reduction, vector attraction reduction and pollutant standards.
- CLASS B BENEFICIAL USE: Generator's sewage sludge is processed in New Jersey by a system designed to prepare Non-Exceptional Quality sewage sludge for beneficial use as a fertilizer or other soil amendment. The process must meet specific but less intense pathogen reduction, vector attraction reduction and pollutant standards which, when combined with site restrictions and management practices, are equally protective of human health and the environment.

[14] https://dep.nj.gov/dwq/residual-management/program_information_data/

Total nitrogen (N) content in biosolids is needed for estimating emissions. The N content depends on the treatment process used and the type of material produced. Based on discussions with staff at the Residuals Management Program, Division of Water Quality, NJDEP, there are currently 3 facilities producing Class A materials and 3 facilities producing Class B materials with fairly stable source composition. The commercial product OceanGro produced by Ocean Co facility has 5% total nitrogen. Review of recent quarterly monitoring reports from the Pemberton Township facility range in concentration of total N 4.71 - 5.43% with the median value in 4.8% dry weight for liquid sludge. These values are assumed to be representative for all Class A and Class B material total N content, respectively. The data is summarized in Table 48 by class. Data prior to 2003 is not available through the online archive of annual reports, therefore an average of total land applied was estimated based on years 2003-2007. See NJ NWL Calculator Manual for instructions on processing (Section: Activity data collection, processing and cleaning/State data 1) and entering activity data on fertilizer applied (Section: Settlements Calculator/Land Area 8).

Table 48. Sludge production (dry tonne) and total N by dry weight (%) in New Jersey (Reference: NJDEP Division of Water Quality, Residuals Management Program).

	Class A			Class B			Class A + Class B
Year	Total sludge (tonne)	Total N proportion (percent)	Total N in sludge (tonne)	Total sludge (tonne)	Total N proportion (percent)	Total N in sludge (tonne)	Total N land applied (tonne)
1990-2002	26,173.58*	5%	1,308.68	5,793.48*	4.8%	278.09	1,586,77
2003	31,927.70	5%	1,596.39	5,737.70	4.8%	275.41	1,871.79
2004	26,509.60	5%	1,325.48	6,023.60	4.8%	289.13	1,614.61
2005	24,720.60	5%	1,236.03	5,852.30	4.8%	280.91	1,516.94
2006	23,885.80	5%	1,194.29	6,298.60	4.8%	302.33	1,496.62
2007	23,824.20	5%	1,191.21	5,055.20	4.8%	242.65	1,433.86
2008	19,763.10	5%	988.16	2,270.40	4.8%	108.98	1,097.13
2009	21,889.90	5%	1,094.50	2,100.10	4.8%	100.80	1,195.30
2010	24,806.10	5%	1,240.31	2,084.20	4.8%	100.04	1,340.35
2011	22,127.70	5%	1,106.39	2,258.20	4.8%	108.39	1,214.78
2012	22,011.00	5%	1,100.55	2,101.30	4.8%	100.86	1,201.41
2013	20,341.30	5%	1,017.07	1,844.20	4.8%	88.52	1,105.59
2014	20,630.50	5%	1,031.53	1,469.20	4.8%	70.52	1,102.05
2015	19,741.90	5%	987.10	1,684.10	4.8%	80.84	1,067.93
2016	16,423.60	5%	821.18	1,451.10	4.8%	69.65	890.83
2017	18,383.50	5%	919.18	1,466.00	4.8%	70.37	989.54
2018	17,886.90	5%	894.35	1,482.40	4.8%	71.16	965.50
2019	17,488.60	5%	874.43	1,377.30	4.8%	66.11	940.54
2020	17,159.10	5%	857.96	1,472.60	4.8%	70.68	928.64
2021	19,616.20	5%	980.81	1,487.10	4.8%	71.38	1,052.19
2022	18,659.90	5%	933.00	1,386.30	4.8%	66.54	999.54
2023	13,066.00	5%	653.30	1,368.60	4.8%	65.69	718.99
*Estimated average based on data from 2003-2007							

Wastewater estimations

The total weight of sludge, and hence total nitrogen (N), removed from wastewater treatment plants for beneficial use is a source of activity data relevant for Settlements because a proportion of the sludge is applied to land as fertilizer in settlement areas. As demonstrated in the diagram in Figure 14, N contained in wastewater can be deposited in different pathways across the wastewater collection and treatment systems. While the removal of sludge from wastewater treatment reduces the total amount of biological oxygen demand (BOD) of the wastewater in the treatment pathways, the total N must be accounted for consistently across categories. For example, total sludge removed that ends up in landfill and/or incinerated must be properly accounted for in the Waste sector, while the portion applied to land is accounted for and reported under Settlements.

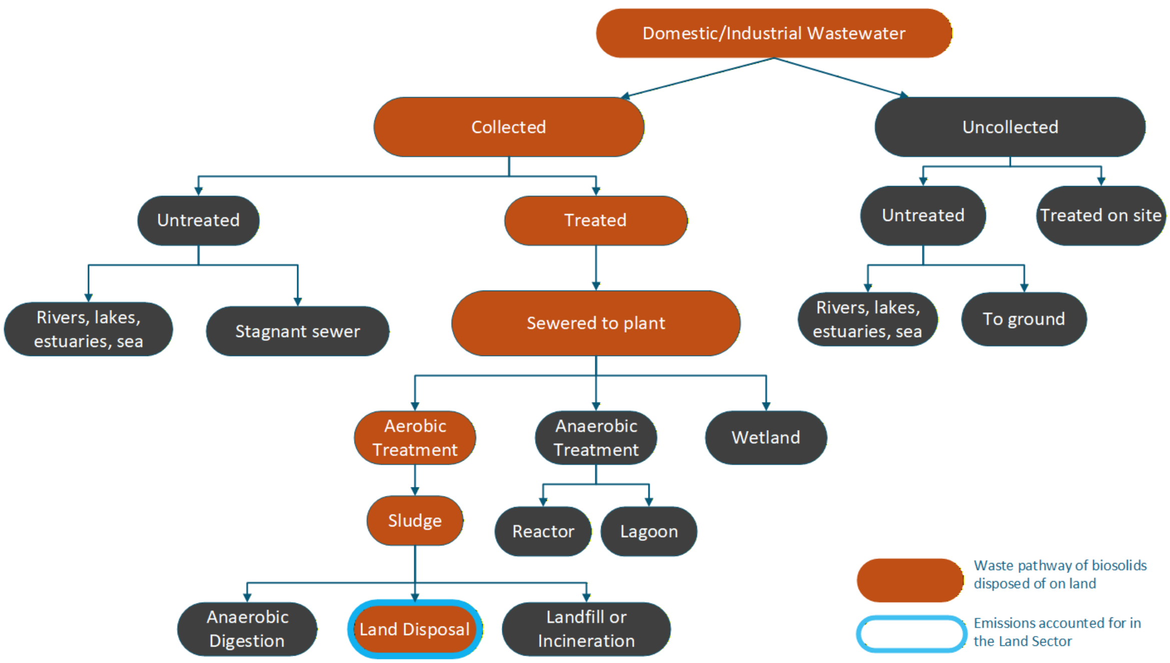

Figure 14. Wastewater treatment systems and discharge pathways resulting of land-disposed biosolids (Adapted from 2006 IPCC Guidelines, Volume 5, Chapter 6).

Therefore, according to New Jersey current GHG Inventory reporting, for all total N estimated to be removed from wastewater treatment as sludge, the following should occur for consistency:

1. In the emissions estimate for wastewater treatment emissions, total N removed as sludge must be documented. If New Jersey is currently using U.S. EPA's SIT tool, sludge removed as total N would be entered in the "Municipal WW, N_2O, effluent" sheet as percentage of biosolids used as fertilizer.
2. Total N removed applied to soil is entered in the NLW Settlements Calculator.

C fluxes from biogenic waste (for information only)

To estimate C fluxes from yard trimmings and food waste, activity data on the amount of landfilled waste and its proportion in the waste stream is needed. Furthermore, the composition of the yard trimmings (i.e., the proportion of grass, leaves, and branches) due to differences in carbon storage and the mass of yard trimmings needs to be disaggregated. The activity data for the total mass of in-state landfilled material[15] is a combination of default data from the SIT (population-based projections) for years 1960-1984 and data taken from New Jersey Municipal Solid Waste reports for 1985-2024. Although this is the same activity data used in estimates of GHG emissions from the Waste sector, the time series inconsistency makes the interpretation of results challenging. The activity data is further confounded by the accounting for waste that was brought into New Jersey from neighboring states. The activity data and parameters to estimate carbon fluxes are provided, however the estimates of C fluxes in this category are provided for information only due very high uncertainty of the estimates.

State waste characterization study from 2022 (NJDEP, 2022) was used to estimate proportion of food waste and yard trimmings as shown in Table 49.

Table 49. Waste characteristics for landfilled municipal solid waste in New Jersey (Reference: NJDEP Division of Sustainable Waste Management, 2022).

% of total waste landfilled													
Waste type	Burlington Co						Mercer Co				Passaic Co	State Ave	State Ave
	Commercial			Residential			Commercial		Residential		Residential		
	Rur	Sub	Urb	Rur	Sub	Urb	Sub	Urb	Sub	Urb	Urban		
Paper	24.1	27.6	25.0	20	18.7	23.2	19.1	25.1	19.2	16.8	24.0	22.1	
Wood	6.8	2.9	2.7	3.2	7.3	7.9	5	11.7	4.3	4.6	5.4	5.6	
Food scraps	18.8	21.6	25.7	18.8	13.4	17.9	20	13.6	19.5	19.8	19.3	18.9	
Yard waste	2.5	5.0	1.9	13.2	2.9	3.1	3.2	1.6	6.7	6.7	3.6	4.6	Proportion of yard waste
Leaves	0.9	1.1	0.8	6.6	1.3	0.7	0.1	0.1	0.8	1.4	1.6	1.4	31%
Grass	1.1	1	0.7	5	1.1	1.1	2.6	1	5.3	4.1	1.1	2.2	48%
Branches	0.5	2.9	0.4	1.6	0.5	1.3	0.5	0.5	0.6	1.2	0.9	1.0	22%

Rur=rural, Sub=suburban, Urb=urban
Paper includes: newspaper, cardboard, office pater, box board, magazines, other paper, compostable paper
Wood includes: particle board, plywood, tree parts, pallets, other wood

Waste compositions for the time series prior to 2020 was taken from US EPA solid waste management data on waste landfilled (US EPA, 2020). Because yard waste is reported as a single category, it was disaggregated based on New Jersey state average provided in Table

[15] A proportion of waste is landfilled outside of the state, which is not included in this analysis.

49. The distribution of biogenic waste for the inventory is estimated according to the values in Table 50.

Table 50. Waste characteristics for landfilled municipal solid waste.

Waste type	1960 - 1969	1970 - 1979	1980 - 1989	1990 - 1999	2000 - 2009^	2010 - 2019^	2020 - 2029#
Food scraps (%)	14.8	11.3	9.5	13.6	17.9	22.2	18.9
Yard waste (%)	24.2	20.5	20.1	17.6	7.8	7.5	4.6
*Grass**	7.4	6.3	6.1	5.4	2.4	2.3	1.4
*Leaves**	11.6	9.8	9.6	8.4	3.7	3.6	2.2
*Branches**	5.2	4.4	4.3	3.8	1.7	1.6	1.0
Paper	30.2	33.2	31.7	30.0	26.6	13.6	22.1
Wood	3.7	3.3	5.1	6.9	7.3	8.3	5.6
Other Types of Waste (%)	27.1	31.7	33.6	31.9	40.4	48.4	48.8
Total (%, must add up to 100%)	100	100	100	100	100	100	100
^ 2000-2009 is an average of 2000 and 2005; 2010-2020 is an average of 2010, 2015, 2017, and 2018							
* For 1960-2019, derived from New Jersey Waste Characterization study conducted in 2022, which shows that yard waste is composed of 31% grass, 48% leaves, and 22% branches (see Table 49)							
# New Jersey waste characterization							
Reference: Advancing Sustainable Materials Management: Facts and Figures, EPA, 2020; Municipal Solid Waste Quantification and Characterization of Burlington, Mercer & Passaic Counties, NJDEP, 2022.							

Biogenic waste weight was determined by multiplying the weight of total municipal solid waste (MSW) landfilled by % composition of the food scraps, grass, leaves, and branches (landfilled in-state, activity data used in estimating waste sector CH_4 emissions).

Emission factors

Settlements remaining settlements

Settlement Trees

To estimate annual C sequestration by urban trees, statewide gross and net sequestration rates determined by Novak (2013) will be used. The study included the following New Jersey communities: Camden, Freehold, Jersey City, Moorestown, and Woodbridge. The parameters used to calculate carbon flux from urban trees in New Jersey are in Table 51.

Table 51. Parameters for estimating urban tree C sequestration (Reference: NGHGI, US EPA 2024).

Parameter	Value	Unit	Converted Value	Unit
Gross Annual Sequestration per Area of Tree Cover	3.21	tonne C hectare $^{-1}$ year^{-1}	1.3	tonne C acre $^{-1}$ year^{-1}
Net Annual Sequestration per Area of Tree Cover	2.34	tonne C hectare $^{-1}$ year^{-1}	0.95	tonne C acre $^{-1}$ year^{-1}
Net:Gross Annual Sequestration Ratio	0.73	Unitless	0.73	Unitless

For estimating C biomass lost when land is converted to other land uses from settlements, FIA urban tree inventory data for Trenton, NJ, from 2022 was utilized. FIA data is queried using the USFS Urban tree platform (https://texasforestinfo.tamu.edu/urbanforeststats/) to obtain data on C density for the two relevant carbon pools: 1) live and dead aboveground and 2) live and dead belowground using parameters listed in Table 52.

Table 52. Carbon density query parameters for the USFS Urban tree inventory.

Selection Parameters	User Selection
Geography	Trenton, NJ
Year	2022
Estimate	Ratio
Numerator	Aboveground carbon, live and dead trees (short tons) Belowground carbon, live and dead trees (short tons)
Denominator	Area of tree cover, in acres
Summary categories, columns	Land use (FIA)
Press RUN	
Urban statistics table	Click "show sampling errors"
Output format	Download statistics in CSV
Unit conversion	Convert short tons to metric tonnes

The aboveground and belowground C biomass density values for live and dead trees are summarized in Table 53 and converted to tonne C per acre. The data is reported for the relevant land use categories. The ones that aligned with the broad categories related to development intensity were selected: open space – recreation/cemetery land use, low intensity development – residential land use, medium intensity development – multi-family residential land use, and high intensity development – commercial/industrial land use. These values are provided here for reference, however they are used in estimating losses of C when settlements are converted to other land categories.

Table 53. Settlement C biomass density derived from US Forest Service Urban Tree Inventory data

	Open space (tonne C acre^{-1})	**Low intensity** (tonne C acre^{-1})	**Medium intensity** (tonne C acre^{-1})	**High intensity** (tonne C acre^{-1})
Aboveground carbon, live and dead trees	11.8±62.1%	27.2±11.1%	20.9±24.7%	30.8±22.4%
Belowground carbon, live and dead trees	2.0±63.7%	4.4±11.5%	3.7±26.7%	4.2±20.2%
± values represent % standard error				

See NJ NWL Calculator Manual for instructions on downloading (Section: Activity data collection, processing, and cleaning/Third party datasets 6) and entering emission parameters for estimating biomass carbon fluxes from urban trees (Section: Settlements Calculator/Emission Factors 11).

N_2O Emissions from soils

Tier 1 emission factors are used to estimate N2O emissions from application of synthetic N fertilizer and biosolids. Both direct and indirect emissions are estimated. The emission parameters are summarized in Table 54.

Table 54. Emission factors for N_2O emissions from managed soils.

Emission factor	Value	Unit
EF_{direct} (synthetic fertilizer, organic amendments)	0.01 (0.002 – 0.018)	kg N2O–N (kg N)$^{-1}$
$EF_{volatilization}$	0.01 (0.002 – 0.018)	kg N2O–N (kg NH_3–N + NO_X–N volatilized)$^{-1}$
$EF_{leaching/runoff}$	0.011 (0.000 – 0.020)	kg N2O–N (kg N leaching/runoff)$^{-1}$
$Frac_{GASF}$ (Volatilization from synthetic fertilizer)	0.11 (0.02 – 0.33)	(kg NH3–N + NOx–N) (kg N applied)$^{-1}$
$Frac_{GASM}$ (Volatilization from all organic N fertilizers applied, and dung and urine deposited by grazing animals)	0.21 (0.00 – 0.31)	(kg NH3–N + NOx–N) (kg N applied or deposited)$^{-1}$
$Frac_{LEACH-(H)}$ (N losses by leaching/runoff in wet climates)	0.24 (0.01 – 0.73)	kg N (kg N additions or deposition by grazing animals)$^{-1}$
Values in () represent uncertainty range Reference: 2019 Refinement to the 2006 IPCC Guidelines, Vol. 4, Ch. 11, Table 11.1 and Table 11.3. Note: conversion to tonnes is not necessary because values are ratios		

Emission parameters for drained organic soils are entered in the NJ Cropland calculator (see NJ NWL Calculator Manual, Section: Settlement Calculator/Land area – 8, Note emission factors for drained organic soil emissions are entered in the same sheet as the land area).

C fluxes from biogenic waste (for information only)

Parameters needed to estimate C fluxes associated with biogenic waste include initial C content, C storage factor, and decay rates. Values used in the NGHGI are used in the New Jersey inventory, shown in Table 55.

Table 55. Emission parameters for estimating for C fluxes for food waste and yard trimmings.

Waste type	Moisture Content (%H2O) *	C Storage Factor (%)*	Initial C Content (%)*	DOC (% wet basis) §	Decay Rate, *k* (year^{-1})
Food scraps	70	16	51	0.15	0.151
Grass	70	53	45	0.2	0.313
Leaves	30	85	46	0.2	0.179
Branches	10	77	49	0.43	0.015
*Reference: NGHGI (US EPA, 2024) § Reference: Table HH-1 to Subpart HH of Part 98, Title 40: Emissions Factors, Oxidation Factors and Methods." Electronic Code of Federal Regulations (eCFR). Garden value is used for grass & leaves, and wood and straw for branches.					

See NJ NWL Calculator Manual for instructions on entering emission parameters for estimating carbon storage from biogenic (Section: Activity data collection, processing, and cleaning/Third party datasets 2).

Drained organic soils

Settlements occurring on organic soils (histosols taxonomic order) are assumed to be drained and would continue to emit CO_2, N_2O, and CH_4. The same parameters are used to estimate emissions for settlements remaining settlements and land converted to settlements. The same emission factors are applied as for cropland. The emission factors are provided in Table 32 (repeated here for convenience).

Parameter	Gas	Value	Unit	Converted value	Unit
EF, direct emissions	CO_2	7.9 (6.5 – 9.4)	tonne CO_2-C hectare^{-1} year^{-1}	3.197	tonne CO_2-C acre^{-1} year^{-1}
EF, indirect emissions	CO_2	0.31 (0.19–0.46)	tonne C hectare^{-1} year^{-1}	0.125	tonne C acre^{-1} year^{-1}
EF, direct emissions	N_2O	13 (8.2 – 18)	kg N_2O-N hectare^{-1} year^{-1}	0.00526091	tonne N_2O-N acre^{-1} year^{-1}
EF, land	CH_4	0 (-2.8 – 2.8)	kg CH_4 hectare^{-1} year^{-1}	0	tonne CH_4 arce^{-1} year^{-1}
EF, ditch	CH_4	1165 (335-1995)	kg CH_4 hectare^{-1} year^{-1}	0.471	tonne CH_4 arce^{-1} year^{-1}
Frac_ditch	CH_4	0.05	unitless	0.05	Unitless
Values in () represent 95% confidence interval. Reference: IPCC 2013 Wetland Supplement, Chap 2.					

See NJ NWL Calculator Manual for instructions on entering emission parameters for estimating biomass carbon fluxes from urban trees (Section: Settlements Calculator/Land area 10).

<u>Land converted to Settlements</u>

Biomass Carbon density

When an acre of land is converted, accumulation of biomass is estimated the same way as for settlements remaining settlements, with an additional step of subtracting carbon density of the land pre-transition due to conversion. The parameters are summarized below in Table 56.

Table 56. Carbon density parameters for Land Converted to Settlements. References provided in each land category section.

Converted from	Pre-transition C density (tonne C acre^{-1})	Converted to	Post-transition C accumulation
Cropland	Orchards - 2.58 Berries - 4.64 Annual crops – 1.9	Settlement	See Table 46 and Table 51
Forest	See Table 14, Table 15, and Table 16 for C stocks for each forest sub-category		
Grassland	AGB: 0.714		

	BGB: 0.079		
Wetlands	Palustrine Forested Wetland – AGB: 25.42/BGB: 4.72/DOM: 13.25 Palustrine Scrub/Shrub Wetland – AGB: 1.28/BGB: 1.47 Palustrine Emergent Wetland – AGB: 1.28/BGB: 1.47 Estuarine Emergent Wetland – AGB: 1.25/BGB: 2.65		
Other Land	0		

See NJ NWL Calculator Manual for instructions on entering emission parameters for estimating biomass carbon fluxes from urban trees (Section: Settlements Calculator/Emission Factors 12).

Soil organic carbon in mineral soils

Fluxes in SOC in mineral soils (not inclusive of histosols taxonomic order) are expected to occur when land is converted. For mineral soils, IPCC default assumption is that it takes 20 years to reach a new equilibrium from the time management changed. However, since currently New Jersey doesn't track land transitions over 20 years, it is assumed that change in mineral soil carbon occurs in the year of transition. IPCC Tier 1 parameters will be used to estimate SOC selected from the parameters listed in Table 57.

Table 57. Soil Carbon stock change factors for Land Converted to Settlement (Reference: 2019 Refinement to IPCC Guidelines, 2013 Wetland Supplement to IPCC Guidelines).

Converted from	Pre-transition stock change factors			Converted to	Post-transition stock change factors		
	F_{LU}	F_{MG}	F_{I}		F_{LU}	F_{MG}	F_{I}
Cropland [a]	0.69	1	1	Settlement	0.69	1	1
Forest	1	1	1		0.69	1	1
Grassland [b]	1	1	1		0.69	1	1
Wetlands – inland on mineral soils [c]	1	1	1		0.71	1	1
Other land [d]	NE	NE	NE		NE	NE	NE

[a] For Cropland converted to Settlement, it is assumed that long-term cultivation, with conventional tillage and medium input cropping is representative of for all cropland converted
[b] For grassland converted to Settlement, nominally managed grassland is assumed
[c] SOC flux estimated for inland wetlands on mineral soils converted to forest, F_{LU} is assumed to be = to cropland with long-term cultivation
[d] For other land converted to forest land, SOC flux is not estimated

Calculations

Carbon fluxes are calculated automatically by the New Jersey Settlements Calculator when activity data and emission parameters are entered by the user (see NJ NWL Calculator Manual, Section: Settlements Calculator/Emission estimates).

Settlements remaining Settlements

Biomass carbon flux

Biomass C is flux estimated for each subcategory and summed together for all land in Settlements

Equation 38. Settlement C flux from urban tress

$$\begin{aligned} Biomass\ C\ flux\ (tonne\ C\ year^{-1}) &= (-1) \times Gross\ sequastration\ rate \\ &\times Net{:}\ Gross\ annual\ sequestration\ ratio \times Settlement\ area\ (acres) \\ &\times \%\ tree\ cover\ in\ settlement\ area \end{aligned}$$

C is converted to CO2 by multiplying by (44/12)

N_2O emissions from managed soils

Direct N_2O-N emissions from synthetic and organic fertilizers

Direct N_2O emissions are estimated for N from synthetic fertilizer and organic amendments and summed together.

Equation 39. Direct N2O emissions from fertilizer applied

$$\text{N}_2\text{O-N (tonne N}_2\text{O-N year}^{-1}) = amount\ of\ N\ in\ fertlizer\ (tonne) \times EF_{direct}$$

NOTE: convert N_2O-N to N_2O (44/28)

Indirect N_2O-N emissions, volatilization

Indirect N_2O emissions from volatilization are estimated for N from synthetic fertilizer and organic amendments and summed together.

Equation 40. Indirect N2O emissions from volatilization

$$\begin{aligned} \text{N}_2\text{O-N volatilized (tonne N}_2\text{O-N year}^{-1}) &= [amount\ of\ N\ in\ synthetic\ fertlizer\ (tonne) \times Frac_{GASF} \\ &+ amound\ of\ N\ in\ organic\ fertilizer\ (tonne) \times Frac_{GASM}] \\ &\times EF_{volatalization} \end{aligned}$$

NOTE: convert N_2O-N to N_2O (44/28)

Indirect N_2O-N emissions, leaching

Indirect N_2O emissions from leaching are estimated for N from synthetic fertilizer and organic amendments and summed together.

Equation 41. Indirect N2O emissions from leaching

$$\begin{aligned} \text{N}_2\text{O-N volatilized(tonne N}_2\text{O-N year}^{-1}) &= total\ amount\ of\ N\ in\ fertlizer\ (tonne) \times Frac_{LEACH-(H)} \\ &\times EF_{leaching} \end{aligned}$$

NOTE: convert N_2O-N to N_2O (44/28)

All N_2O emissions, direct and indirect, are summed together for each year.

C flux from biogenic waste and HWP (for information only)

C fluxes from disposal of biogenic waste were calculated using the IPCC Waste Model[16] which uses IPCC's First Order Decay (FOD) to estimate methane emissions and long-term C storage in solid waste management facilities (2019 Refinement to the 2006 IPCC Guidelines). The tool was modified to allow disaggregation of yard waste into leaves, grass, and branches. Additionally, it allows for data entry of wood, paper, and other waste types to enable estimation of long-term C storage. The tool was also amended to allow entry of total waste disposed data in short tons for conversion to Gg. See NJ NWL Calculator Manual (Section: Activity data collection, processing and cleaning/State data 2) on entering biogenic waste activity data and parameters. The long-term C estimation output from the tool was copied and pasted into the New Jersey Settlements calculator for yard waste and food scraps C fluxes and into the New Jersey Forest calculator for wood and paper C fluxes, as a component of the HWP C pool. This process can be replicated for future inventory years as data on total waste landfilled becomes more reliable.

Land converted to Settlements

Biomass carbon flux (conversion)

Only emissions from loss of biomass pre-conversion are estimated. Biomass carbon fluxes due to urban tree growth is estimated for all settlements together (see Equation 38).

Equation 42. LCS biomass carbon flux

$$Biomass\ C\ flux\ (tonne\ C\ year^{-1}) = Transitional\ area\ (acres) \times C\ density_{pre\_transition}$$

NOTE: C density includes all relevant carbon pools – for forest land and forested wetland classes: aboveground biomass, below ground biomass, dead organic matter; for all others: aboveground biomass and below ground biomass.

C is converted to CO2 by multiplying by (44/12)

Soil organic carbon flux

SOC flux in mineral soil is calculated using Equation 1 (without dividing by 20)

NOTE: SOC flux is estimated for newly converted land each year, which is linearly interpolated between datasets. Therefore, SOC flux is equal for each year within a period between datasets.

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[16] The IPCC Waste Model (MS Excel) Available for download and free access at: https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol5.html

C is converted to CO2 by multiplying by (44/12)

Drained organic soil emissions

Annual emissions are estimated for each gas for each year in the time series, converted to CO2e and totaled.

CO_2 emissions from drained soils

Equation 43. Drained Organic Soils on-site CO2 emissions

a. $$Annual\ on-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ settlements\ area\ (acre) \times\ EF$$

Equation 44. Drained Organic Soils off-site CO2 emissions

b. $$Annual\ off-site\ CO_2-C\ emissions\ from\ drained\ soils\ (tonne\ C\ year^{-1}) = Drained\ settlements\ area\ (acre) \times\ EF$$

NOTE: convert CO_2-C to CO_2 (44/12)

N_2O emissions from drained soils

Equation 45. Drained Organic Soils N2O emissions

$$N_2O\ emissions\ from\ drained\ soils(tonne\ N_2O-N\ year^{-1}) = [Drained\ settlements\ area\ (acres) \times\ EF]$$

NOTE: convert N_2O-N to N_2O (44/28)

CH_4 emissions from drained soils

Equation 46. Drained Organic Soils CH4 emissions

$$CH_4\ emissions\ from\ drained\ soils\ (tonne\ CH_4\ year^{-1}) = \left\{Drained\ settlements\ area\ (acres)\ \times \begin{bmatrix} ((1-Frac_{ditch}) \times EF_{land}) \\ + \\ ((Frac_{ditch}) \times EF_{ditch}) \end{bmatrix}\right\}$$

Emissions and removals are provided for settlements remaining settlements and land converted to settlements for each Anderson sub-class, and by carbon pool as applicable. The summary tab in the Forest Calculator provides total emission by main categories.

Uncertainty

Uncertainty associated with changes in carbon stocks in settlement trees includes the uncertainty associated with settlement area, percent tree cover in developed land and how well it represents percent tree cover in settlement areas, and estimates of gross and net carbon sequestration for New Jersey. Uncertainty in estimating N2O emissions is associated with quantifying N inputs from synthetic fertilizer and biosolids. There is not state level data on application of fertilizers and organic amendments in settlements. When estimating C flux in landfilled biogenic waste, uncertainty is associated with activity data related to total tonnage of waste and distribution of waste in New Jersey landfills.

Future improvements

Conducting urban tree inventories and analyzing the data to derive C accumulation rates and more accurate representation of tree cover would improve the accuracy of urban tree biomass estimates. Currently, there are several areas in addition to Trenton that will have tree inventory data collected by the USFS. The GHG inventory team could collaborate with the New Jersey Forest Service to develop state specific emission parameters for estimating biomass carbon in trees. Furthermore, activity data on fertilizer application in the state, disaggregated by farm and non-farm use would improve N_2O emission estimates. Likewise, data on landfilled waste and its distribution by type would be beneficial in better quantifying long term stored carbon in landfills.

OTHER LANDS

Data is currently lacking to derive parameters to estimate GHG emissions and removals on lands classified under this category, therefore, it is not estimated.

BIOMASS BURNING

Overview

Wildfires and prescribed burning occur in New Jersey. Fires may occur on Forest Lands, Cropland, and Grassland. Non-CO_2 emissions (CH_4 and N_2O) from biomass burning are included in the inventory. CO_2 losses are accounted for in changes in biomass C stocks and are provided for information only. The methodology utilized in estimating non-CO_2 emissions from biomass burning is based on the Wildland Fire Emissions Inventory System calculator (WFEIS, https://wfeis.mtri.org/calculator)[17], the same tool used by the National GHG Inventory. The WFEIS calculator estimates emissions with the *Consume* model utilizing spatially explicit data on burn areas, fuelbed types, and weather conditions. Fuelbed represents the type of vegetation consumed during the fire (Landfire Program, USDA & US Dept of Interior).

Activity data

Activity data needed to estimate emissions from biomass burning is:

- Total burn area and
- Fuel available for combustion

New Jersey has only recently begun to systematically document spatial extent of fires on natural lands. To estimate non-CO_2 emissions from biomass burning in New Jersey, total burn area from Monitoring Trends in Burn Severity (MTBS) perimeters for 1990-2024 were utilized. Note that MTBS perimeters include data on all fires of 1,000 acres or greater in the western United States and 500 acres or greater in the eastern United States. Therefore, the emissions are likely underestimated.[18]

For information on fuel available for combustions, the Fuel Characteristic Classification System (FCCS) was utilized. In FCCS, fuel beds represent the structure and composition of wildland fuels and include categorization by land time which can be used to disaggregate emission estimates by land categories used in the inventory. The WFEIS also uses meteorological data to simulate conditions at the time of the fire to estimate emissions.

WFEIS estimates emissions for fires regardless of land category they occur on, therefore biomass burning emissions are reported in a separate section combined for all land rather than by land category. Fuelbed designation are be used to disaggregate emissions by land type to provide a more detailed look at the distribution of fire emissions across the state.

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[17] Estimates for the timeseries 1990-2024 are based on WFEIS version v2.2022.08, detailed tool description is available here: https://doi.org/10.1175/EI-D-14-0002.1

[18] The degree of underestimation needs to be further evaluated by comparing to state data which should capture smaller burns.

Emission factors

Emission parameters for estimating burning emissions include combustion factors for particular fuel types and emission factors for particular gases. These are integrated into the model based on fuel type determined by the location of the fire. The emission factors are also determined within the model based on fuelbed type. The model provides the numerous outputs related to fire emissions, however, for this inventory CH_4 and CO_2 emissions are of relevance. The model does not calculate N_2O emissions, which are derived by scaling estimated CO_2 emissions based on the average N_2O to CO_2 ratio of 0.000166 (Larkin et al. 2014; IPCC 2019).

Calculations

Emission calculations are performed externally by the WFEIS Calculator, with activity data, relevant parameters and emission estimates documented and archived in the New Jersey Biomass Burning calculator. To extract all necessary data for input to New Jersey Biomass Burning Calculator, follow the steps outlined in the NJ NWL Calculator Manual (Section: Activity data collection, processing, and cleaning/Third party datasets 1) or the NJ Biomass Burning Calculator directly.

Uncertainty

The biggest uncertainties in WFEIS come from accuracy in mapping fire perimeters, estimating true fuel loads and consumption, and applying generalized emission factors, where each step compounds uncertainty in the final emissions estimate.

Activity data on burn perimeters (location, size, timing) may have errors due to limitations of satellite data (cloud cover, resolution) and interpretation (classification errors). Small or patchy burns may be under detected. In fact, burns under 500 acres are not reported in the MTBS fire perimeters for the eastern part of the US. Furthermore, WFEIS relies on FCCS (Fuel Characteristic Classification System) maps for fuel loading estimates, which generalize vegetation and fuel conditions over large areas. Actual on-the-ground variability in fuel amount, type, and moisture can be substantial. Emission factors utilized by WFEIS are based on published average emission factors for different pollutants by fuel type and combustion phase. In reality, emission factors vary with fuel composition, fire intensity, and environmental conditions.

Future improvements

To improve accuracy of emission estimates, collection and use of state level data on burn perimeters and burn types (wildfire, prescribed burns, others) is recommended. It is likely that emissions are underestimated because burn areas over 500 acres are included in MTBS dataset.

The following additional datasets provided by the WFEIS calculator were considered:

- The Terra and Aqua combined MCD64A1 Burned area (v6.1) burned area product from MODIS for 2000-202*x*. This data product is a monthly, global product containing per-pixel burned-area and quality information. The burned-area mapping approach employs 500-m Moderate Resolution Imaging Spectroradiometer (MODIS) Surface Reflectance imagery coupled with 1-km MODIS Active Fire (MCD14ML) observations.

- Wildland Fire Interagency Geospatial Services (WFIGS) perimeters (archive) for 1990 – 202*x*, provided by the WFIGS Group includes authoritative geospatial data products under the interagency Wildland Fire Data Program. This source represents the "WFIGS - Wildland Fire Perimeters Full History" dataset in addition to the year-to-date perimeters dataset.

These data sources were not selected for emissions estimates since MODIS only covers part of the timeseries, and while WFIGS goes back to 1950s, it has much fewer records than the MTBS data, suggesting data gaps. These can be used to address limited information on smaller fires, however, additional statistical data processing would be required to harmonize multiple sources of activity data. It is recommended, therefore, that state level data is used if available in the future, enabling more granular and comprehensive activity data on burn areas. WFEIS calculator tool allows for users to upload a shapefile with burn areas. The attribute table also needs to include the date of the fire events to be able to link it with meteorological data needed by the model.

Improvements in activity data on burn areas collected at the state level can improve the accuracy of the estimates. This would likely include smaller fires that may not be captured by the MTBS dataset. Furthermore, the if documented and characterized at the state level, fires can be disaggregated further by fire type, for example, wildfires or prescribed burns, which may be relevant for management decisions.

Quality Assurance and Quality Control Procedures

The planning and implementation of quality assurance and quality control (QA/QC) procedures are necessary inputs to the development of GHG inventories. QA/QC procedures help identify improvement options to enhance transparency, accuracy, consistency, comparability, and completeness in GHG inventories. Conducting QA/QC also builds confidence in GHG inventories. This section provides an overview of a QA/QC procedures for the New Jersey NWL GHG inventory.

The IPCC defines Quality control and quality assurance as follows:

- **Quality Control (QC)** – a system of routine technical activities implemented by the inventory compilers to measure and control the quality of the inventory as it is prepared.
- **Quality Assurance (QA)** – a planned system of review procedures conducted by personnel not involved in the inventory development process. QA procedures are performed upon a completed inventory following the implementation of QC procedures and preferably by independent third parties. A basic expert peer review is part of this process.
- **Verification** - Verification refers to the collection of activities and procedures conducted during the planning and development, or after completion of an inventory that can help establish its reliability for the intended applications of the inventory. For use in inventories, verification refers specifically to those methods that are external to the inventory and apply independent data, including comparisons with inventory estimates made by other bodies or through alternative methods.

QC is part of the inventory compiler's day-to-day work. In contrast, external staff who are not involved in the inventory compilation perform QA as an additional quality process. Verification activities may be constituents of both QA and QC, depending on the methods used and the stage at which independent information is used.

QC is further divided into general and category-specific QC procedures. General QC procedures include generic quality checks related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories. Category-specific QC procedures complement general inventory QC procedures. Category-specific QC is directed at specific types of data used in the methods for individual source or sink categories. These procedures require knowledge of the specific category, the types of data available, and the parameters associated with emissions or removals, and are performed in addition to the general QC checks. QA and QC are critical components of an inventory management system because when they are implemented effectively, they identify and correct errors as well as drive inventory improvement. Therefore, a fundamental element of the inventory management system is a written QA/QC plan. An effective QA/QC plan includes the following elements:

- Identification of personnel responsible for coordinating QA/QC activities
- Timeline for implementing QA/QC procedures
- General QC procedures
- Category-specific QC procedures
- QA review procedures
- Reporting, documentation, and archiving procedures
- A prioritized QA/QC improvement list, which should be reviewed regularly and used to guide improvements

QA/QC Plan

The New Jersey inventory QA/QC plan outlines QA/QC activities to be performed, the personnel responsible for these activities, the schedule for completing these activities, and a list of future planned QA/QC improvements. NWL sector QA/QC process can be included in the broader New Jersey GHG inventory QA/QC plan to ensure continuity and consistency.

Identify QA/QC personnel

The responsibilities of the personnel involved in implementing the QA/QC activities are described below. The roles are flexible and may overlap. Therefore, one staff member might cover multiple categories. Inventory staff may have a joint inventory compilation-QA/QC role. It is unnecessary to limit one person's role to coordinating inventory QA/QC. Staff assigned to these roles are listed in the Appendix.

- NWL QA/QC Coordinator: Develop and coordinate the implementation of the QA/QC plan for the NWL sector of the GHG inventory
- Category Lead(s): Develop and implement general and/or category specific (as appropriate) QA/QC procedures.

- Expert reviewer: Conduct 3rd party review of the inventory. Ensure the role of the expert is carefully defined and agreed upon. The expert can be within the agency, or an international expert.

Develop a timeline for distributing the QA/QC plan and QA/QC activities

It is essential to communicate the contents of the QA/QC plan to inventory team members, data providers, and outside experts involved in quality assurance of the GHG inventory so that the procedures can be effectively implemented, evaluated, and improved without unnecessary duplication. Furthermore, data providers may have their own QA/QC procedures, and the inventory QA/QC plan should take that into account. The timeline for conducting the QA/QC actions as outlined in Table 58. This timeline should be aligned with the overall inventory process described in the section on inventory process as appropriate. The inventory team can use Table 58 to document QA/QC planning and implementation and document improvements for future inventory cycles.

Table 58. QA/QC activities and timeline utilized in the inventory preparation cycle

Task	Timeline	Outcome	Potential Improvements
Create (or update) the QA/QC plan	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Identify new or confirm participation of current QA/QC personnel	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Discuss/refine QA/QC plan at the inventory inception meeting	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Review and document existing QA/QC procedures implemented by data providers	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Distribute the QA/QC plan	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Develop QA/QC checklists	At the beginning of each inventory cycle	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Distribute QA/QC checklists and materials for review	When draft inventory is compiled	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Collect reviewed materials	Following review of draft inventory	*[To be filled out each inventory cycle by inventory QAQC coordinator]*	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Other	TBD		

Establish general and category-specific QC procedures

The QA/QC procedures include generic quality checks related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories.

A minimum set of QC procedures is followed each inventory cycle for all categories to ensure that basic standards of quality are met. These standards generally focus on the processing, handling, documenting, archiving, and reporting procedures common to all categories. Table 59 and Table 60 provide lists of general and category-specific QA/QC activities, respectively. The listed activities are expected to be conducted as applicable. Compilers should use expert judgement in identified any additional QA/QC activities to ensure proper review and update the QA/QC plan accordingly. These tables can be used by staff responsible for QA/QC tasks as checklists.

Table 59. General QC activities to be conducted during the preparation of the inventory

QC Activity	Procedures	Task Completed by
	Data Gathering, Input, and Handling Checks	
Check that assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters are documented	• Cross check descriptions of activity data and emission factors with information on categories and ensure that these are properly recorded and archived. • Record if there are multiple sources of the same activity data, and, if possible, document the reasons for any differences. • Cross-check land use definitions in the NGHGI and note any discrepancies.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check for transcription errors in data input and references	• Confirm that bibliographical data references are properly cited in the internal documentation (see Methods and Data section, if applicable). • Cross check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors. Record the findings of these cross checks. Pay particular attention to systematic differences. Identify steps to reduce the error rate in the future. Add these improvement steps to the QA/QC development plan. • Utilize electronic data where possible to minimize transcription errors. • Check that calculation tools are used in a manner that minimizes user/entry error: ○ Do not “hardwire” factors into formulas. ○ Do not edit or make changes to calculation tools which were developed by a third-party. When necessary, enlist the support of an experienced professional. ○ Create automatic look-up tables for common values used throughout calculations. ○ Use cell protection so fixed data cannot accidentally be changed. ○ Do no remove existing cell protection during data entry and calculations. ○ Build in automated checks, such as computational checks for calculations, or range checks for input data, mass	*[To be filled out each inventory cycle by inventory QAQC coordinator]*

QC Activity	Procedures	Task Completed by
	balance checks, internal consistency checks within and between spreadsheets. o Ensure spreadsheets have clear instructions for updating and a description of how the spreadsheet works. o Properly following existing instructions from third-party (or State-specific) calculation tools. o Ensure spreadsheets include a record of how they have been implemented and checked.	
Check that emissions/removals are calculated correctly	• Reproduce a representative sample of emissions/removals calculations. • If higher-tier methods or models are used, selectively reproduce complex model calculations with abbreviated calculations to judge relative accuracy. This could be done using IPCC Tier 1 methods, for example. • In all cases, record the work done and the findings. Record any improvements identified (in the appropriate Templates, if applicable).	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check that calculation tools are applied properly	• Check the most appropriate version of a publicly available tool is either being utilized. For example, the latest version may contain refined parameters. • Check if tools developed in-house are free from data processing errors. For example, ensure all formulas are free from return errors. • Check whether all completion steps were taken within each calculation tool and no field is left empty, if their completion is required for emissions estimates.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check that parameter and emission/removal units are correctly recorded and that appropriate conversion factors are used	• Check that activity data was properly entered following the units identified by calculation tools. • Check that units are properly labeled in calculation sheets and the Methods and Data section, if applicable. • Check that units are correctly carried through from beginning to end of calculations. • Check that conversion factors and other parameters are correct. • Check that temporal and spatial adjustment factors are used correctly.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check the integrity of database files	• Confirm that the appropriate data processing steps are correctly represented in the database. • Confirm that data relationships are correctly represented in the database. • Ensure that data fields are properly labeled and have the correct design specifications. • Ensure that adequate documentation of database and model structure and operation are archived.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check for consistency in data between categories	• Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emissions/removals calculations. • If using Excel, establish a “master set” of constants that all spreadsheets refer to rather than a set of constants in each spreadsheet.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*

QC Activity	Procedures	Task Completed by
Check that the movement of inventory data among processing steps is correct	• Check that emissions/removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries. • Check that emissions/removals data are correctly transcribed between different intermediate products.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check that confidential data are appropriately protected	• Check that only the GHG inventory compilation team can handle/access confidential data. • Check that such data are reported in compliance with requirements agreed on with the data source (if applicable).	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check that uncertainties in emissions and removals are estimated and calculated correctly	• If using expert judgement, check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate. • Check that qualifications, assumptions and expert judgements are recorded. • Check that calculated uncertainties are complete and calculated correctly. • If necessary, duplicate uncertainty calculations on a small sample of the probability distributions used by Monte Carlo analyses (for example, using uncertainty calculations according to Approach 1).	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Data Documentation		
Review internal documentation and archiving	• Check that there is detailed internal documentation to support the estimates and enable duplication of calculations, using Methods and Data section, if applicable. • Check that every primary data element has a reference for the source of the data (via cell comments or another system of notation). • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review. • Check that the archive is closed and retained securely following completion of the inventory. • Check integrity of any data archiving arrangements of outside organizations involved in inventory preparation.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Calculation Checks		
Check methodological and data changes resulting in recalculations	• Check for temporal consistency in time series input data for each category. • Check for consistency in the algorithm/method used for calculations throughout the time series. • Reproduce a representative sample of emission/removal calculations to ensure mathematical correctness.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Check time series consistency	• Check for temporal consistency in time series input data for each category. • Check for consistency in the algorithm/method used for calculations throughout the time series. • Check methodological and data changes resulting in recalculations. • Check that the effects of mitigation activities have been appropriately reflected in time series calculations. Higher IPCC methodologies might be needed to accurately capture the effects of mitigation activities	*[To be filled out each inventory cycle by inventory QAQC coordinator]*

QC Activity	Procedures	Task Completed by
Check completeness	• Confirm that estimates are reported for all categories and for all years from the appropriate base year over the period of the current inventory. • For subcategories, confirm that the entire category is being covered. • Confirm that if an emissions or removal estimate is omitted for any given category, documentation to explain or clarify the omission is included, and notation keys are used for that category. (This may include categories that were also omitted from the previous inventory.) • Provide clear definitions of "Other" type categories. • Check that known data gaps that result in incomplete category emissions/removals estimates are documented, including qualitative evaluation of the importance of the estimate in relation to total net emissions (e.g., subcategories classified as "not estimated").	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Trend checks	• For each category, compare current inventory estimates to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any differences. Significant changes in emissions or removals from previous years may indicate possible input or calculation errors. • Check value of implied emission factors (aggregate emissions/removals divided by activity data) across time series to confirm that changes in emissions or removals are being reported. • Check if there are any unusual or unexplained trends in activity data or other parameters across the time series.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Reference: This list has been adapted from IPCC Good Practice Guidance and the 2006 IPCC Guidelines for National GHG Inventories.		

Table 60. Category-specific QC procedures (template, make copies of as many categories as needed)

QC Activity	Procedures	Task Completed by
	Emission Factor QC	
Assess the applicability of IPCC default emission factors	• Evaluate whether national conditions are similar to those used to develop the IPCC default factors. • Compare default factors to site or plant-level factors. • Consider options for obtaining country-specific or state-specific factors. • Document results of this assessment.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Review location-specific emission factors	• QC the background data used to develop the country-specific or state-specific factor to assess adequacy of the emission factors and the QA/QC performed during their development ○ E.g., if based on measurement studies, did measurement program included QC procedures ○ E.g., understand characteristics of data (e.g., completeness, etc.) • Assess whether secondary studies used to develop state-specific or region-specific factors used (at a minimum) general QC activities.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*

QC Activity	Procedures	Task Completed by
	• Compare state-, region- or country-specific factors to IPCC defaults; document any significant discrepancies. • Compare emission factors to site or plant-level factors. • Compare to factors from other states if available (also see IPCC Emission Factor Database). • Conduct reference calculations that use stoichiometric ratios and conservation of mass and land. • Document results of this assessment.	
Review measurements	• Determine if national or international (e.g., ISO) standards were used in measurements. • Ensure measurement equipment is calibrated and maintained properly. • Compare direct measurements with IPCC or other published default factors; document any significant discrepancies.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Activity Data QC		
Review national-level activity data	• Determine the level of QC performed by the data collection agency. If inadequate, consider alternative data sources. Adjust the relevant uncertainty accordingly. • Compare activity data from multiple references (e.g., other independently compiled data) if possible, including data time series	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Review site-specific activity data	• Determine if national or international (e.g., ISO) standards were used in collecting or generating data. • Compare aggregated site-specific data (e.g., production) to national statistics/data. • Compare data across similar sites. • Compare top-down and bottom-up estimates for similar orders of magnitude.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
Trend checks of activity data	• Compare data to previous year's data and review any sharp increases or decreases. ○ If national activity data for any year diverge greatly from the historical trend, they should be checked for errors. ○ If a calculation error is not detected, the reason for the sharp change in activity should be confirmed and documented.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
QC uncertainty estimates	• Apply QC techniques to uncertainty estimates. • Review uncertainty calculations. • Document uncertainty assumptions and qualifications of any experts consulted.	*[To be filled out each inventory cycle by inventory QAQC coordinator]*
GHG Estimate QC/Verification		
Verify GHG estimates	• Compare estimates to other independently compiled estimates as available. • If using higher-tier methods or models, apply lower-tier methods for comparison • Document, report, and archive verification findings and any further actions (e.g., additional QC, improvement plans).	*[To be filled out each inventory cycle by inventory QAQC coordinator]*

Document recommendations from experts' review

Quality Assurance involves expert reviewers not involved in preparing the inventory and a peer review process. QA activities follow QC activities and complement QC activities.

Expert review offers the opportunity to uncover technical issues related to the application of methodologies, selection of activity data, and development and choice of emission factors. The comments of the expert reviewers are be reviewed and addressed, as appropriate, prior to the finalization of the inventory, and documented/archived appropriately to ensure transparency and for reference of future compilation teams. Experts are independent of the inventory agency, and affiliated with other state agencies, national agencies, research facilities, or other organizations with relevant expertise in GHG emission estimation methodologies, activity data, or other parameters. If third party reviewers are unavailable, staff from another part of the inventory agency not involved in the portion of the inventory under review can fulfill this role.

Key categories are given priority for review, as well as source and sink categories where significant changes in methodology or data have been made. The Appendix identifies the experts who are to review the land sector section of the NWL sector of the GHG inventory. Add major improvements identified by expert reviewers to the GHG IIP.

Key Category Analysis

The concept of "key categories" aims to help decision makers prioritize resources for improving GHG inventories over time and reduce uncertainties. IPCC defines key categories as: "a category that is prioritized within the national inventory system because its estimate has a significant influence on total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals." In international reporting, when a category is key, countries need to take certain steps to report on them and ensure that accuracy of reporting improves over time. This same concept is useful and applicable to state level GHG inventories.

In the context of state GHG inventories, key categories can be identified as those categories that have the largest influence on the level and trend of emissions over time (once a time series of emission estimates is prepared). In addition, per the 2006 IPCC Guidelines, conducting a key category analysis (KCA) reflecting relative uncertainty assessments may identify additional key categories (e.g., smaller but more uncertain sources will appear to contribute more to the emission total than they would without considering uncertainty).

The results of the KCA provide the inventory team (and decision makers) with a list of their most important inventory categories and helps prioritize efforts in improving the GHG inventory over time. To improve the inventory, it may be necessary to consider applying more rigorous or higher tier methodologies, collect more detailed activity data, or develop location-specific emission factors. These activities all require additional resources, and it is not possible to make improvements for every inventory category at once. The KCA provides an important input to the IIP. KCA applies to the entire GHG inventory, however, categories within the NWL sector can be disaggregated to more closely assess their contribution to state GHG emissions and removals. Guidance below was adapted to help conduct sectoral KCA for the NWL component of the state inventory.

In the context of international reporting to the UNFCCC, the IPCC guidelines provide specific parameters and methods for conducting the KCA. The method outlined in this section is based on the IPCC guidelines, however, it's amended to fit the state context.

KCA can be determined in the following ways:

- Qualitative criteria – qualitative criteria can be used to assess which categories should be prioritized. Examples include completeness, lack of quantified uncertainty assessment, or mitigation priority.
- Level assessment – the magnitude of each category compared to total NWL emissions/removals in the current year; categories are sorted by decreasing order of magnitude with key categories adding up to a certain value (e.g., 95% under IPCC guidelines)
- Trend assessment – the magnitude of each category, and its influence on the overall trend when comparing the current year and the reference year to determine if emissions are increasing or decreasing

Qualitative criteria

Key categories using qualitative criteria are documented in Table 61. Refer to the 2006 IPCC Guidelines, Vol. 1, Ch. 4 for more information on qualitative criteria.

Table 61. Key categories identified using qualitative criteria

Category	Gas	Criteria
[To be filled out by inventory coordinator]		
[To be filled out by inventory coordinator]		
[To be filled out by inventory coordinator]		
[To be filled out by inventory coordinator]		

Quantitative assessment

Preliminary level and trend assessments are conducted for the New Jersey State Greenhouse Gas Emissions Inventory. The reference year was 1990 and the assessment year was 2020, as the last year with estimates from all categories.

Level assessment

Level assessment is determined using equation below[19]:

$$L_{x,t} = \frac{|E_{x,t}|}{\sum_i |E_{i,t}|}$$

[19] 2019 Refinement to the 2006 IPCC Guidelines, Vol. 1, Ch.4, Equation 4.1

Where

$L_{x,t}$ = level assessment for source or sink *x* in year *t* (latest inventory)

$|E_{x,t}|$ = absolute value of emission or removal estimate of source or sink category *x* in year *t*

$\sum|E_{i,t}|$ = total contribution, which is the sum of the absolute values of emissions and removals for all n categories (i=1, ... x, n) in year t calculated using the aggregation level chosen for key category analysis. Because both emissions and removals are entered with positive sign, the total contribution/level can be larger than state's total net emissions.

The categories that sum up to an agreed upon level are considered key categories (IPCC default is 95%). Key category level assessment for year 2020 is provided in Table 62.

*Table 62. Key category level assessment based on contribution to total NWL emissions for year 2020, () indicate removals, **bold** font indicates key categories*

Category	2020 Year Emissions (tonne CO_2e), $E_{x,t}$	$\|E_{x,t}\|$	Level assessment, $L_{x,t}$	Cumulative of $L_{x,t}$
Settlements remaining settlements	(2,650,312)	2,650,312	0.379	0.379
Forest remaining forest	(2,048,340)	2,048,340	0.293	0.672
Wetlands remaining wetlands	(692,263)	692,263	0.099	0.771
Drained organic soils/Settlements	679,977	679,977	0.097	0.868
Land converted to settlements	459,704	459,704	0.066	0.934
Cropland remaining cropland	167,288	167,288	0.024	0.958
Drained organic soils/Cropland	95,619	95,619	0.014	0.972
Land converted to wetland	94,776	94,776	0.014	0.985
Land converted to cropland	43,805	43,805	0.006	0.992
Land converted to grassland	(34,394)	34,394	0.005	0.996
Land converted to forest	(20,045)	20,045	0.003	0.999
Emissions from biomass burning	4,223	4,223	0.001	1.000
Grassland remaining grassland	710	710	0.000	1.000
Total	(3,899,391)	6,991,316		

Trend assessment

Trend assessment is conducted using both the reference year estimates (typically base year) and current/latest year estimates. Another year (if changes are expected in a particular period) can be selected as a reference year for trend assessment.

The trend assessment identifies categories whose trends differ significantly from the trend of the total inventory, regardless of whether the category's trend is increasing or decreasing, or it is a sink or source.

The IPCC defines the "inventory category trend" as the change in net emissions from the base year to the current year, as a percentage of current year net emissions from that inventory category. Trend assessment is calculated using the formula below[20]:

$$T_{x,t} = \left| \frac{E_{x,t} - E_{x,0}}{\sum_i E_{i,t} - \sum_i E_{i,0}} \right|$$

Where

$T_{x,t}$ = trend assessment for source or sink *x* in year *t* as compared to the base year (year 0)

$E_{x,t}$ and $E_{x,0}$ = values of emission or removal estimate of source or sink category *x* in years *t* and 0, respectively

$\sum E_{i,t}$ and $\sum E_{i,0}$ = total inventory estimates in years *t* and 0, respectively, for i=1,....n

Categories with trends that diverge the most from the total trend should be identified as key when this difference is weighted by the level of emissions or removals of the category in the base year. Key category trend assessment for year 2020 is provided in Table 63. Reference year is 1990.

[20] 2019 Refinement to the 2006 IPCC Guidelines, Vol. 1, Ch.4, Equation 4.2

*Table 63. Key category trend assessment for 2020 relative reference year 1990, () indicate removals, **bold** font indicates key categories*

Category	1990 Emissions (tonne CO_2e)	2020 Emissions (tonne CO_2e)	Trend assessment, $T_{x,t}$	% Contribution to trend, $T_{x,t}/ \sum T_{i,t}$	Cumulative contribution to trend
Land converted to settlements	1,398,037	459,704	0.586	0.319	0.319
Settlements remaining settlements	(2,023,542)	(2,650,312)	0.391	0.213	0.533
Wetlands remaining wetlands	(1,188,297)	(692,263)	0.310	0.169	0.701
Cropland remaining cropland	560,919	167,288	0.246	0.134	0.835
Land converted to grassland	116,561	(34,394)	0.094	0.051	0.886
Land converted to forest	(131,853)	(20,045)	0.070	0.038	0.925
Land converted to wetland	150,935	94,776	0.035	0.019	0.944
Forest remaining forest	(2,102,439)	(2,048,340)	0.034	0.018	0.962
Land converted to cropland	82,380	43,805	0.024	0.013	0.975
Drained organic soils/Cropland	131,486	95,619	0.022	0.012	0.987
Grassland remaining grassland	29,301	710	0.018	0.010	0.997
Drained organic soils/Settlements	673,458	679,977	0.004	0.002	0.999
Emissions from biomass burning	6,300	4,223	0.001	0.001	1.000
Total	(2,297,261)	(3,899,391)			

The steps to conduct KCA should be documented along with any supporting information and results.

GHG inventory improvements

KCA can help identify areas of improvements and prioritize improvements identified through other components of the inventory process. Improvements to the GHG inventory identified as a result of the KCA should be documented and included in the IIP. Check the method used to estimate emissions or removals from each of the key categories, and examine the quality and accuracy of the activity data, emission factors, and model used to estimate emissions or removals. Identify strategies to improve accuracy and reduce uncertainty. Record suggested improvements to the inventory in the IIP.

Archiving System

An inventory archive is a collection of information related to the GHG inventory compilation process, reporting, and institutional arrangements. Having easy access to such information will help:

- Current and future inventory compilers understand previously used data, methodologies, structures, and processes so that they can prepare the inventory efficiently and in a manner that is consistent with prior inventories;
- Increase the sustainability of the GHG inventory management system over time; and
- Increase the transparency of the inventory reporting process.

Archiving of the documents pertaining to the NWL sector of the inventory should be integrated into the general archiving procedure of the state GHG inventory. The archiving coordinator should ensure that the inventory Archiving System (AS) facilitates archival and evaluation of the current information before the next GHG inventory compilation cycle begins. Additionally, they should document potential improvements to the AS based on lessons learned from archiving materials or accessing these materials later. An AS enables the efficient compilation of an archive that is consistent across all sectors and categories. The archiving coordinator may need to work with the inventory coordinator and other inventory team members to refine the archiving system.

The archiving coordinator should archive all material associated with each GHG inventory compilation cycle and not overwrite material. An inventory archive differs from routine electronic file backup. The archive should be a collection of materials that specifically facilitates replicating the compilation steps of a prior GHG inventory.

The inventory archive should include the following materials:

- Inventory compilation plan
- Institutional arrangements including contact information
- Methods and data
- Any files used for calculation (e.g., spreadsheets, models, databases, inventory calculation software)
- QA/QC procedures and results
- Key category analysis
- Drafts and final electronic versions of the inventory report (e.g., State Inventory Document and any submitted common reporting tables, and any technical annexes)
- Internal and external review comments and responses
- Archiving system
- Improvement plan

The proposed structure for an archiving system is shown in Figure 15. The archival plan identifies roles and responsibilities of staff involved in the archiving process (Table 68), what information created during the compilation of your inventory will be archived (Table 69), where it will be archived, when it will be archived, by whom it will be archived, and who will have access to it (Table 70). The tables with this information are in the Appendix.

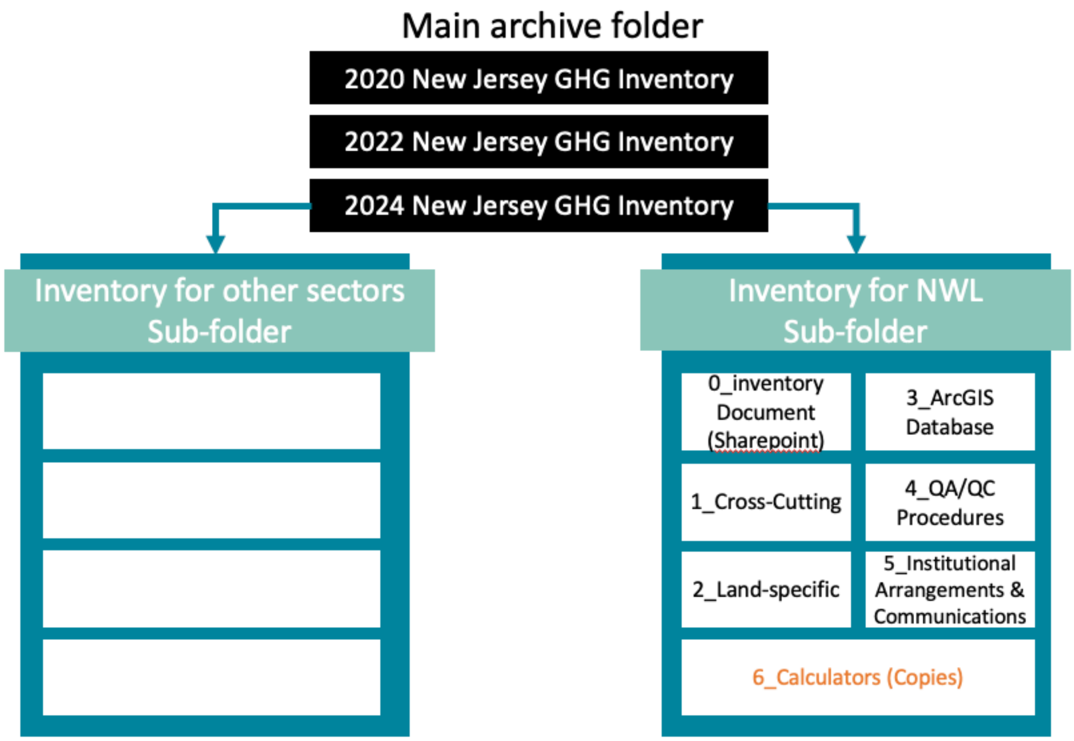

Figure 15. Proposed archival structure for the NWL inventory

GHG inventory improvements

As the inventory process evolves, specific components of the archiving system will likely require additional improvements. They should be documented here in Table 64 and in the (IIP).

Table 64. Improvements to the NWL inventory archiving system

Issue	Potential Improvement	Steps Needed to Implement Improvement
[To be filled out by inventory coordinator]	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
[To be filled out by inventory coordinator]	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
[To be filled out by inventory coordinator]	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

Inventory Improvement Plan

The Inventory Improvement Plan (IIP) presents options for improving the state GHG inventory system to support compilation of a high-quality inventory consistent with the *2006 IPCC Guidelines*. The IIP guides future efforts to increase the transparency, consistency, comparability, completeness, and accuracy of future inventories and informs the overall improvement of the GHG inventory, including strengthening institutional capacity over the coming years. These improvements have been identified through documentation of existing institutional arrangements, category-by-category analyses of methods and data, QA/QC procedures, key categories, and the archiving system in the previous sections of the document. Table 65 summarizes proposed improvement. When improvements are implemented resulting in revised methodology, the entire time series needs to be recalculated using a new method to ensure time series consistency. If not feasible, variability in methodology needs to be clearly documented and explained.

Table 65. Summary of proposed improvements

#	Key Category L (Level) T(Trend)	Category Name	Issue	Improvement Option	Priority of Improvement	Timing of Improvement	Additional Information Needed for Improvement
1	NA	Cross-cutting/Land Classification	20-year transition is not tracked	Revise LULC processing protocol to document transitions over a 20 year period, not just from the last data set	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
2	NA	Cross-cutting/Soil Organic Carbon Reference	Aggregated SOC_{ref} for mineral soil	Utilize SSURGO data and estimate separate SOCref values for different mineral soil taxonomies to differentiate between soil types	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
3	NA	Cross-cutting/Organic soil definitions (focus on cropland and settlements)	Organic soils definition is based on soil taxonomy such that all histosols	Refine definition of organic soils based on additional soil attributes	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

			are designated as organic soils				
4	L,T	Forest Land Remaining Forest Land	Revising carbon density parameters	US Forest Service FIA revised allometric equations in early 2026 resulting in slightly higher carbon density values. These should be used to adjust the parameters used in the calculations of the inventory	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
5	L,T	Forest Land Remaining Forest Land	Assumption that area is not changing before next LULC data set is released	Projections about area could be made for years following the latest data set, either extrapolated from historic data or based on surrogate data, e.g., NLCD data. Once new data is published, the projected years need to be recalculated	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
6	L,T	Forest Land Remaining Forest Land	Planation forest type assumption	Collect data on forest plantation species and select appropriate emission factors if current assumption needs to be adjusted	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
7	T	Land Converted to Forest Land	Default carbon accumulation rates for plantation forest categories	Derive New Jersey specific C accumulation rates for young plantation forests	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
8	T	Land Converted to Forest Land	Simulated carbon accumulation rates for land	Revise accumulation rates once data is collected on recently burned sites	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

			converted to forest with severely burned vegetation				
9	L,T	Cropland Remaining Cropland	Land classifications too broad, native grasslands that are used for grazing should be reclassified as grasslands	Develop protocol to add new land classes that disaggregate cropland and pasture/grasslands and consider including pasture/grassland under the grassland category	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
10	L,T	Cropland Remaining Cropland	Lacking management data	Establish data collection process to document land management practices by key cropping systems – document tillage practices, residue management, fertilization levels	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
11	L,T	Cropland Remaining Cropland	Default parameters are used for estimating soil and woody crop biomass C fluxes	Conduct studies to derive New Jersey specific biomass C densities for woody perennial crops	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
12		Drained Organic Soils/Cropland	Default drained organic soil emission parameters	Conduct measurements to derive New Jersey specific emission parameters	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
13		Grassland Remaining Grassland	Lacking management data	Establish data collection process to document land management practices – document grazing activities, improvement/restoration of degraded pastures	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

14		Grassland Remaining Grassland	Biomass C density estimate for woody vegetation only, from forest plots; perennial herbaceous C density parameters not available	Conduct measurements to refine New Jersey specific emission parameters for grassland vegetation (shrubs/perennial herbaceous vegetation)	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
15	L,T	Wetlands Remaining Wetlands (coastal and inland)	Delineation of coastal zones is static	Update dataset used to delineate coastal and inland using most recent elevation maps, can be done with each new LULC dataset	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
16	L,T	Wetlands Remaining Wetlands (inland)	Classification of areas is inconsistent especially for forested wetlands and deciduous forest	Conduct additional data collection to improve land classification for forested wetlands; verify imagery data with on the ground surveys and develop a process for adjusting/re-classification	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
17	L,T	Wetlands Remaining Wetlands (inland)	Assumptions in estimating inland wetland emissions and removals	Conduct additional research to derive emission factors applicable to inland wetlands, specifically for soil carbon	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
18	L,T	Settlements Remaining Settlements	Fertilizer use in settlements is limited	Establish data collection process to document fertilizer use in settlement areas – quantity and N content	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
19	L,T	Settlements Remaining Settlements	Representative biomass C density and	Conduct additional urban tree inventories to derive more	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

			accumulation rates for urban trees are not available	representative biomass C density and accumulation parameters			
20		Biomass burning	Only emissions from large wildfires are captured	Establish a process for annual digital documentation of wildfires and prescribed burns – burn perimeters and for prescribed burns, tons of fuel burned, if area/perimeter is not available or applicable	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
21	Information only	Settlements Remaining Settlements	Waste characterization data is limited	Conduct regular waste characterization studies to capture trends in long term carbon storage fluxes from biogenic waste and harvested wood products	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
22		Drained Organic soils/Forest and Grassland	Proportion of area where organic soils are drained	Estimate proportion of drained organic soils occurring in New Jersey in forests and grasslands	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

References

Arias-Ortiz, A., Wolfe, J., Bridgham, S. D., Knox, S., McNicol, G., Needelman, B. A., Shahan, J., Stuart-Haëntjens, E. J., Windham-Myers, L., Oikawa, P. Y., Baldocchi, D. D., Caplan, J. S., Capooci, M., Czapla, K. M., Derby, R. K., Diefenderfer, H. L., Forbrich, I., Groseclose, G., Keller, J. K., ... Holmquist, J. R. 2024. Methane fluxes in tidal marshes of the conterminous United States. Global Change Biology, 30, e17462. https://doi.org/10.1111/gcb.17462

Artigas, F., Shin, J.Y., Hobble, C., Marti-Donati, A., Schäfer, K.V. and Pechmann, I., 2015. Long term carbon storage potential and CO2 sink strength of a restored salt marsh in New Jersey. Agricultural and Forest Meteorology, 200, pp.313-321.

Boyd, B.M., and C.K. Sommerfield. 2016. Marsh accretion and sediment accumulation in a managed tidal wetland complex of Delaware Bay. Ecological Engineering 92, 37-46.

Brakebill, J.W. and Gronberg, J.M. (2017) County-Level Estimates of Nitrogen and Phosphorus from Commercial Fertilizer for the Conterminous United States, 1987-2012. U.S. Geological Survey, https://doi.org/10.5066/F7H41PKX.

Champlin, L., Velinsky, D., Tucker, K., Sommerfield, C., St. Laurent, K. and Watson, E., 2020. Carbon sequestration rate estimates in Delaware Bay and Barnegat Bay tidal wetlands using interpolation mapping. Data, 5, 11.

Charpentier, M., C. Wigmand, and J. Hyman. "Estimates of Carbon Sequestration in Tidal Coastal Wetlands Along the US East Coast" Presented at 25th Annual Northeast ARC Users Group Conference, Newport, RI, November 7 – 10, 2010 (EPA Website 10/4/2019).

Cui, S., Liu, P., Guo, H. *et al.* Wetland hydrological dynamics and methane emissions. *Commun Earth Environ* **5**, 470 (2024). https://doi.org/10.1038/s43247-024-01635-w

Green et al. 2021. Coastal Wetlands in National Greenhouse Gas Inventories. Advice on reporting emissions and removal from management of Blue Carbon ecosystems. https://bluecarbonpartnership.org/wp-content/uploads/2021/11/Coastal-Wetlands-in-National-Greenhouse-Gas-Inventories.pdf

Domke, G.M., Woodall, C.W., Smith, J.E., Westfall, J.A., McRoberts, R.E. (2012) Consequences of alternative tree-level biomass estimation procedures on U.S. forest carbon stock estimates. Forest Ecology and Management. 270: 108-116.

Domke, G.M., Smith, J.E., and Woodall, C.W. (2011) Accounting for density reduction and structural loss in standing dead trees: Implications for forest biomass and carbon stock estimates in the United States. Carbon Balance and Management. 6:14.

Domke GM, Perry CH, Walters BF, Nave LE, Woodall CW, Swanston CW (2017). Toward inventory-based estimates of soil organic carbon in forests of the United States.

Ecological Applications : a Publication of the Ecological Society of America. PMID 28165643 DOI: 10.1002/Eap.1516

De la Cruz, F.B. and M.A. Barlaz (2010) "Estimation of Waste Component Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data" Environmental Science & Technology 44:4722– 4728.

Domke GM, Perry CH, Walters BF, Woodall CW, Russell MB, Smith JE (2016). Estimating litter carbon stocks on forest land in the United States. The Science of the Total Environment. 557: 469-478. PMID 27017077 DOI: 10.1016/J.Scitotenv.2016.03.090

Falcone, J.A., 2021, Tabular county-level nitrogen and phosphorus estimates from fertilizer and manure for approximately 5-year periods from 1950 to 2017: U.S. Geological Survey data release, https://doi.org/10.5066/P9VSQN3C

Holmquist, J.R., Windham-Myers, L., Bernal, B., Byrd, K.B., Crooks, S., Gonneea, M.E., Herold, N., Knox, S.H., Kroeger, K.D., McCombs, J. and Megonigal, J.P., 2018. Uncertainty in United States coastal wetland greenhouse gas inventorying. Environmental Research Letters, 13(11), p.115005.

Hoover, C.M., Smith, J.E. Aboveground live tree carbon stock and change in forests of conterminous United States: influence of stand age. Carbon Balance and Management 18, 7 (2023). https://doi.org/10.1186/s13021-023-00227-z

IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC. 2014. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M., & Troxler, T.G. (*eds*). IPCC, Switzerland.

IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

Larkin, N. K., S. Raffuse, and T. T. Strand (2014) Wildland fire emissions, carbon, and climate: U.S. emissions inventories. For. Ecol. Manage. 317:61–69.

Lathrop Richard. 2015. Documentation for TNC Restoration Explorer App. Center for Remote Sensing & Spatial Analysis, Rutgers University. Accessed June 2025. https://maps.coastalresilience.org/newjersey/plugins/living-shorelines-nj/resources/Methods.pdf

Denise Nemeth, John G. Lambrinos, Bernadine C. Strik (2017). The effects of long-term management on patterns of carbon storage in a northern highbush blueberry production system. Science of The Total Environment, Volume 579, p. 1084-1093. https://doi.org/10.1016/j.scitotenv.2016.11.077.

NJ Department of Environmental Protection (NJDEP). 2008. Appendix H. Forestry and Land-Use Change. *In* New Jersey Greenhouse Gas Inventory and Reference Case Projections 1990-2020. Accessed December 2024. https://dep.nj.gov/wp-content/uploads/ghg/ghg-inventory-report_2008.pdf

NJ Department of Environmental Protection (NJDEP). 2022. Municipal Solid Waste Quantification and Characterization of Burlington, Mercer & Passaic Counties, NJDEP, 2022. https://www.nj.gov/dep/dshw/recycling/WasteCharacteriazation.pdf

NJ Department of Environmental Protection (NJDEP). 2024a. NJ Greenhouse Gas Emissions Inventory Report Years 1990-2021. Accessed November 2024. https://dep.nj.gov/wp-content/uploads/ghg/2024-ghg-inventory-report.pdf

NJ Department of Environmental Protection (NJDEP). 2024b. Land Use/Land Cover 2020 Update, Edition 20241101 (Land_lu_2020) (Web Mercator ArcGIS Online Service). Dataset. Accessed December 2024. https://www.nj.gov/dep/gis/digidownload/zips/OpenData/Land_lu_2020.zip

NOAA. 2016. “Name of Data Set.” Coastal Change Analysis Program (C-CAP) Regional Land Cover. NOAA Office for Coastal Management. Charleston, SC. Accessed November 2024. www.coast.noaa.gov/htdata/raster1/landcover/bulkdownload/30m_lc/.

NOAA 2017. Method description: Detailed method for mapping sea level rise marsh migration. NOAA Office for Coastal Management. Charleston, SC. Accessed November 2024. https://coast.noaa.gov/data/digitalcoast/pdf/slr-marsh-migration-methods.pdf

Nowak, D.J. and E. Greenfield (2010) Evaluating the National Land Cover Database tree canopy and impervious cover estimates across the conterminous United States: A comparison with photo-interpreted estimates. Environmental Management. 46: 378-390.

Nowak, D.J., E.J. Greenfield, R.E. Hoehn, and E. Lapoint (2013) Carbon storage and sequestration by trees in urban and community areas of the United States.” Environmental Pollution 178: 229-236.

National Marine Fisheries Service (2022). Fisheries of the United States, 2020. U.S. Department of Commerce, NOAA Current Fishery Statistics No. 2020. Accessed December 2024. https://www.fisheries.noaa.gov/ national/sustainable-fisheries/fisheries-united-states

Ogle, S.M., M.D. Eve, F.J. Breidt, and K. Paustian (2003) “Uncertainty in estimating land use and management impacts on soil organic carbon storage for U.S. agroecosystems between 1982 and 1997.” Global Change Biology 9:1521-1542.

Ogle, S.M., F.J. Breidt, and K. Paustian. (2006) “Bias and variance in model results due to spatial scaling of measurements for parameterization in regional assessments.” Global Change Biology 12:516-523.

Ogle, S.M., F.J. Breidt, M. Easter, S. Williams, K. Killian, and K. Paustian (2010) “Scale and uncertainty in modeled soil organic carbon stock changes for U.S. croplands using a process-based model.” Global Change Biology 16:810-822.

Ogle, S.M., G. Domke, W.A. Kurz, M.T. Rocha, T. Huffman, A. Swan, J.E. Smith, C. Woodall, T. Krug (2018) Delineating managed land for reporting greenhouse gas emissions and removals to the United Nations Framework Convention on Climate Change. Carbon Balance and Management 13:9.

Oshins, C. and D. Block (2000) “Feedstock Composition at Composting Sites.” Biocycle 41(9):31–34.

Poffenbarger, Hanna & Needelman, Brian & Megonigal, Patrick. (2011). Salinity Influence on Methane Emissions from Tidal Marshes. Wetlands. 31. 831-842. 10.1007/s13157-011-0197-0.

Sapkota Y, Berkowitz JF, Stagg CL and Busby RR (2025). A synthesis of freshwater forested wetland soil organic carbon storage. Front. For. Glob. Change 8:1528440. doi: 10.3389/ffgc.2025.1528440

The Nature Conservancy (TNC). 2015. “Restoration Explorer.” Accessed December 2024. https://coastalresilience.org/project/restoration-explorer

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at https://websoilsurvey.nrcs.usda.gov/.

US Environmental Protection Agency (EPA), Advancing Sustainable Materials Management: Facts and Figures Report, December 2020.

US Environmental Protection Agency (EPA). 2024. Chapter 6: Land Use, Land-Use Change, and Forestry. *In:* Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022. EPA 430-D-24-011. 178 pages. Accessed December 2024. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

US Geological Survey (USGS). 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U. S. Geological Survey Professional Paper 964.

Wang, F., K.D. Kroeger, M.E. Gonnea, J.W. Pohlman, and J. Tang. 2019. Water Salinity and inundation control soil carbon decomposition during salt marsh restoration: An incubation experiment. Ecology and Evolution, 9, 1911-1921. https://doi.org/10.1002/ece3.4884

Westfall, J.A., Coulston, J.W., Gray, A.N., Shaw, J.D., Radtke, P.J., Walker, D.M., Weiskittel, A.R., MacFarlane, D.W., Affleck, D.L.R., Zhao, D., Temesgen, H., Poudel, K.P., Frank, J.M., Prisley, S.P., Wang, Y., Sánchez Meador, A.J., Auty, D., and Domke, G.M. 2023. A national-scale tree volume, biomass, and carbon modeling system for the United States. Gen. Tech. Rep. WO-104.

Woodall CW, D'Amato AW, Bradford JB, Finley AO (2011). Effects of stand and inter-specific stocking on maximizing standing tree carbon stocks in the Eastern United States *Forest Science*. 57: 365-378.

WFEIS (2023) Wildland Fire Emissions Inventory System, home page. https://wfeis.mtri.org/.

WFIGS (2023) WFIGS, The Wildland Fire Interagency Geospatial Service Interagency Fire Perimeters. National Interagency Fire Center. https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-interagency-fire-perimeters/explore?location=0.000000%2C0.000000%2C1.82.

Derived from: A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U. S. Geological Survey Professional Paper 964, 1976; edited by NJDEP, OIRM, BGIA, 1998, 2000, 2001, 2002, 2007, 2012, 2015, 2020 (URL: https://www.nj.gov/dep/gis/digidownload/metadata/lulc15/anderson2015.html)

Appendix

Roles and responsibilities

Staff currently serving the roles (cross-cutting and for each category) described in the SOP are identified in Table 66. Other roles may be identified (e.g., staff who tracks capacity building efforts, staff who may use inventory information for mitigation tracking) in the future and added in Table 66. Additional rows can be added to capture data providers and other supporting roles.

Table 66. NWL Inventory team roster. Updated last on [September 1, 2025]

Role	Name	Department	Contact information	Description
Inventory compilation				
NWL Sector Coordinator	Chris Barry	Climate Change, Clean Energy & Sustainability	Chris.Barry@dep.nj.gov	Coordinates the preparation of the NWL sector of the state-wide GHG inventory (including all the categories)
Archiving Coordinator	Chris Barry	Climate Change, Clean Energy & Sustainability	Chris.Barry@dep.nj.gov	Conduct archiving of the NWL inventory data and reports as part of the overall state GHG inventory archive
QA/QC Coordinator				Lead the QA/QC of the NWL GHG inventory
Uncertainty Analysis Coordinator	Dan Clark	Climate Change, Clean Energy & Sustainability	Daniel.Clark@dep.nj.gov	Lead the uncertainty analysis of the NWL GHG inventory
Key Category Analysis (KCA) Lead	Dan Clark and Chris Barry	Climate Change, Clean Energy & Sustainability	Daniel.Clark@dep.nj.gov Chris.Barry@dep.nj.gov	Conduct the KCA for the state GHG Inventory including NWL sector
Inventory support				
New Jersey NWL Spreadsheet Calculator Management	Dan Clark	Climate Change, Clean Energy & Sustainability	Daniel.Clark@dep.nj.gov	Review function and implement updates/enhancements
Data provision: Derive Forest Lands parameters	Lauren Siclare/Bill Zipse	Bur of Forest Mgt - Trenton Staff	lauren.siclare@dep.nj.gov william.zipse@dep.nj.gov	Conduct research, data analysis, share data with inventory team (e.g., NWL Sector Coordinator), share data with BGIS team

Role	Name	Department	Contact information	Description
Data provision and processing: Provide land classification data	John Tyrawski	DOIT Geographic Info Systems	john.tyrawski@dep.nj.gov	Provide land use and land use change data and related data products needed, share data with inventory team (e.g., NWL Sector Coordinator), coordinate with Forest service team
Data provision: Wetlands parameters	Metthea Yepsen Joshua Moody	Division of Science and Research	Metthea.Yepsen@dep.nj.gov Joshua.Moody@dep.nj.gov	Conduct research, data collection and analysis
Data provision: Cropland data and parameters (e.g., land stratification by management)	Rachel DeFlumeri	Agriculture Resource Specialist	Rachel.DeFlumeri@ag.nj.gov	Collect and provide data
Data provision: Biomass burning data	Bill Donnelly	Bur of Forest Fire Mgt	william.donnelly@dep.nj.gov	Conduct data analysis; share data with inventory team (e.g., NWL Sector Coordinator)
Data provision: Biological Waste management data	Kyle McHenry	Bur of SW Permitting	kyle.mchenry@dep.nj.gov	Provide data on waste quantity and composition
Data provision: Biosolids land application	John Murray	NJDEP, Division of Water Quality Bureau of Ground Water, Residuals, and Permit Administration	john.murray@dep.nj.gov	Provide data on biosolid quantity and composition

Table 67. External reviewers/experts (fill in rows as needed). Updated last on [September 1, 2025]

Name	Organization	Position	Area of Expertise	Contact Information
Richard G. Lathrop Jr.	Rutgers University, Dept. of Ecology, Evolution and Natural Resources	Faculty, Director of Center for Remote Sensing & Spatial Analysis	Landscape ecology and geography with the application of geo-spatial information technology; The structure and function of coupled human-environmental systems at broader landscape to regional scales	Email: lathrop@crssa.rutgers.edu
Matthew Olson	Stockton University	Assistant Professor of Environmental Studies	Forestry	Matthew.Olson@stockton.edu
Marjorie Kaplan	Rutgers University, School of Environmental and Biological Sciences, Rutgers Climate and Energy Institute	Associate Director	Resiliency planning and policy, community-based planning, and stakeholder engagement; climate and public health; climate and natural and working lands	mbk65@envsci.rutgers.edu
Jason Grabosky	Rutgers University, Department of Ecology, Evolution, and Natural Resources	Faculty	Urban tree management in the development and maintenance of urban landscapes; managing stormwater for urban sustainability using trees and structural soils	grabosky@sebs.rutgers.edu

The archival plan roles and responsibilities of staff involved in the archiving process (Table 68), what information created during the compilation of your inventory will be archived (Table 69), where it will be archived, when it will be archived, by whom it will be archived, and who will have access to it (Table 70).

Table 68. Inventory team members involved in archiving activities and their responsibilities. Updated last on [September 1, 2025]

Role	Responsibility
Inventory Coordinator	*[To be filled out by inventory coordinator]*
Archiving Coordinator	*[To be filled out by inventory coordinator]*
Inventory Compilers	*[To be filled out by inventory coordinator]*

Table 69. Materials to be archived. Updated last on [September 1, 2025]

Materials to be archived	Staff from whom the materials should be obtained	Point in time at which the materials should be archived
Inventory compilation plan	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Institutional arrangements	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Methods and data	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Any files used for calculation (e.g., spreadsheets, models, databases, SIT)	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
QA/QC procedures and results	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Key category analysis	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Drafts and final electronic versions of the inventory report (e.g., State Inventory Document and any submitted common reporting tables, and any technical annexes)	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Internal and external review comments and responses	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Archiving system	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*
Improvement plan	*[To be filled out by inventory coordinator]*	*[To be filled out by inventory coordinator]*

Table 70. Archive location, backup, and structure. Updated last on [September 1, 2025]

Archiving process	Description
Archived inventory files location	*[To be filled out by inventory coordinator]*
Personnel with access to the archive	*[To be filled out by inventory coordinator]*
Accessing the archive instructions	*[To be filled out by inventory coordinator]*
Backup of the archive location	*[To be filled out by inventory coordinator]*
Backup procedures	*[To be filled out by inventory coordinator]*
Archive structure	*[To be filled out by inventory coordinator]*
Archive file naming convention	*[To be filled out by inventory coordinator]*

Land use matrix

A land-use change matrix is a table that tracks how areas of land move between categories (such as forest, cropland, grassland, wetlands, and settlements) over a given time period. The diagonal cells show land that remained in the same category, while the off-diagonal cells show conversions (e.g., forest converted to cropland).

Such a table is important because it provides the foundation for GHG inventories in the land sector and land management analysis. By quantifying how much land changes use, the matrix allows estimation of associated carbon stock changes and emissions or removals, supports consistency checks across datasets, and makes land-use dynamics transparent for policy and reporting.

- Cells = the area (e.g., acres) of land that transitioned from one category to another over the reporting period.
    - The diagonal (row = column) shows land that stayed in the same category ("land remaining land").
    - Off-diagonal cells show conversions (e.g., Forest → Cropland, Grassland → Settlements).
- Rows = the land-use category at the *start* of the period
- Columns = the land-use category at the *end* of the period

The land-use change matrix is provided for 2015-2020 land transitions in New Jersey for reference.

2015-2020

	Cropland	Forest	Grassland	Other land	Settlements	Wetlands	Total Initial Area
Cropland	474,006.74	102.79	3,175.01	203.48	8,373.72	174.64	486,036.38
Forest	442.44	1,349,750.15	875.24	861.73	9,696.40	124.77	1,361,750.73
Grassland	1,247.27	3,672.26	153,310.51	536.61	4,221.89	227.59	163,216.13
Other land	31.17	13.25	583.79	36,344.27	907.06	1,432.23	39,311.77
Settlements	1,216.47	237.40	3,389.37	431.92	1,629,797.71	451.91	1,635,524.79
Wetlands	49.67	16.07	1,719.21	1,432.23	2,236.88	2,187,523.64	2,192,977.70
Total Final Area	476,993.75	1,353,791.93	163,053.13	39,810.25	1,655,233.67	2,189,934.78	5,878,817.51

Estimated Level of Effort for GHG Inventory data preparation

Task	Frequency/Level of Effort (LOE)	Lead
Activity data preparation		
Step 1: Map NJ LULC classes to GHG inventory categories *w/Python script*. Python script will edit attribute table based on land use code and insert new table with classification. Preliminary steps:	Frequency: For every new LULC dataset release, ~5 years LOE: 2 days of work to run the scripts and QA/QC the outputs	*[To be filled out by inventory coordinator]*

Task	Frequency/Level of Effort (LOE)	Lead
- Review mapping scheme provided and adjusted if needed - Review Python scripts provided and adjusted entries where needed based on the mapping scheme GHG Categories - Forest land remaining forest land - Land converted to forest lands - Cropland remaining cropland - Land converted to cropland - Grassland remaining grassland - Land converted to grassland - Wetlands remaining wetlands - Land converted to wetlands - Settlements remaining settlements - Land converted to settlements - Other land remaining other land - Land converted to other land		
Step 2: Join NJ LULC dataset, from Step 1, with SSURGO soil data to add soil attributed to land use area by soil taxonomic order (mineral/organic). Add attribute for soil type (mineral – all taxonomic orders except histosols; organic – histosols) *w/ Python script*. Preliminary steps: - Download most recent NJ SSURGO data - Join attributes to NJ's boundary from Valu1 and Component tables from SSURGO - Run python script to conduct spatial join of land use map from Step 1 and SSURGO layer.	Frequency: For every new LULC dataset release, ~5 years LOE: 1 day to download updated SSURGO data, join data, and QA/QC outputs	*[To be filled out by inventory coordinator]*

Task	Frequency/Level of Effort (LOE)	Lead
Step 3: Join NJ LULC dataset from Step 2 with the hydrology layer and classify polygons by coastal and inland taxonomy. Add hydrology attributes (coastal – below the Mean High Water Line; inland – above the Mean High Water Line) *w/ Python Script. Relevant for Wetlands remaining wetlands, and land converted to wetlands only.* Preliminary steps: - Identify most recent hydrology data, e.g., mean high water line the state has Post processing step: - Run spatial join python script for wetlands and hydrology.	For every new LULC dataset release, ~5 years LOE: 1 day, join data, and QA/QC outputs	*[To be filled out by inventory coordinator]*
Step 4: Join NJ LULC dataset from Step 3 with the salinity layer and add attribute with weighted average salinity for each wetland subclass *w/ Python Script. Relevant for Coastal wetlands (remaining and converted to).* Preliminary steps: - Review salinity data provided and check for any updates with Division of Science and Research, use the most recent one available if updated Post processing step: • Run spatial join python script using output from step 2 and joining with the salinity layer attributed.	Frequency: For every new LULC dataset release, ~5 years LOE: 1 day, join data, and QA/QC outputs	*[To be filled out by inventory coordinator]*
Step 5: Run python script to generate multiple data reports from attribute tables of the outputs from Step 2 and 4 for use in GHG calculators.	Frequency: For every new LULC dataset release, ~5 years	*[To be filled out by inventory coordinator]*

Task	Frequency/Level of Effort (LOE)	Lead
Post processing step: • Run python script to generate data summary which results in multiple excel tables • Excel tables to be shared with inventory team containing land categorized by GHG category, soil type, hydrology and including salinity.	LOE: 0.5 day, join data, and QA/QC outputs	
Emission parameter preparation		
Mapping parameters from forest type group to NJ LULC (Anderson) classifications for updated Forest Inventory Analysis program data. Parameters are calculated by averaging forest type group values across NJ LULC forest classes **w/ Python script** Preliminary steps: - NJ Forest Service alerts the inventory team that updated parameters can be derived from FIA and provides updated C density and C accumulation rate parameters from the latest FIA inventory for each forest type group - Review provided map of forest type groups (US FS map clipped to New Jersey) Output: - Excel table with recalculated C stock/C accumulation parameters	Frequency: For every new LULC dataset release, ~5 years LOE: 1 day, join data, and QA/QC outputs	*[To be filled out by inventory coordinator]*
Land conversion tracking (new)		
Track land conversions over a 20-year period Steps to implement: - Add an attribute for tracking time since converted	Frequency: For every new LULC dataset release, ~5 years	*[To be filled out by inventory coordinator]*

Task	Frequency/Level of Effort (LOE)	Lead
- Implement logic to assign to land remaining category when tracker reaches 20 years. - Adjust Python script in Step 1 to assign categories to land remaining and land converted - Test with a small batch of data	LOE: 5-8 days, to set up the new process for tracking period of time in transition during the first cycle, 1-2 days in the following cycles	