New Hampshire
1993
Greenhouse Gas Inventory

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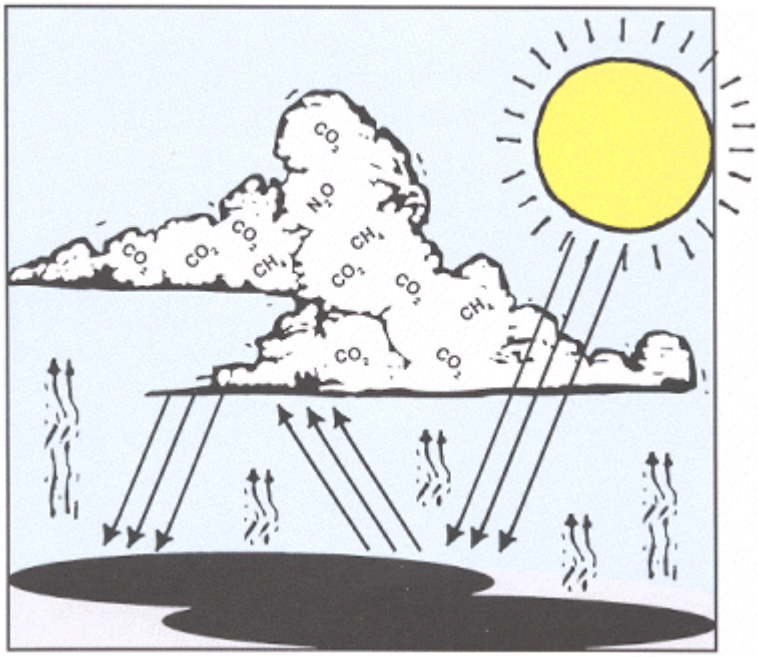

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iv Executive Summary

A. The Greenhouse Phenomenon and Its Consequences

Life on earth is possible because the sun's energy warms the earth and its atmosphere. As this warmth radiates back into space, a portion is absorbed by a delicate balance of heat trapping gases in the atmosphere, creating an insulating layer. The insulating layer, functioning much as a conventional greenhouse does, acts to elevate temperatures on earth. This "greenhouse effect" is a necessary natural global mechanism. Without it, the earth's climate would be much colder and more hostile to human life. Anthropogenic additions to greenhouse gases (GHG) have led to an "enhanced greenhouse effect" often referred to as global warming. Scientific investigations over the past decade have identified a correlation of recorded temperature increases with global GHG emissions, substantiated by physical and numerical modeling results, strongly suggesting that human activity is a significant contributor to global warming.

Large scale climatic changes resulting from global warming have the potential to significantly affect human health, well being, and economic activity over the long term. The U.S. Environmental Protection Agency has listed nearly forty types of impacts on health, renewable resources, water quality and supply, ecosystems, aesthetics, and weather-related disasters. In New Hampshire, impacts on the state's ecosystems and aesthetics are of particular concern given the dependence of the state's economy on tourism and, to a lesser degree, on forestry and fishing. Although New Hampshire cannot solve the global warming problem on its own, it is clear that, by acting in concert with other states and the U.S. and international governments, New Hampshire can do much to meet its obligation as part of the large-scale joint effort now underway. Such efforts are known to produce substantial secondary benefits relating to energy conservation, greater efficiencies in waste and material management, and improved air and water quality through general reductions in pollutant emissions.

B. Identification and Quantification of Greenhouse Gases (GHGs)

Greenhouse gases most commonly identified with the greenhouse effect and global warming are:

Carbon Dioxide (CO_2)
Methane (CH_4)
Nitrous Oxide (N_2O)

Numerous other substances, emitted in much smaller amounts also contribute to the effect. However, due to their overall preponderance of total emissions, only the three listed above

are accounted for in this inventory.

New Hampshire's GHG emissions inventory has been compiled for the analysis year 1993. The inventory is organized into five parts, or activity "sectors":

1. Energy Use
2. Industrial Processes
3. Waste Management
4. Agriculture
5. Land Use

GHG emissions from these sectors are described in detail and quantified in Parts I-V of this document. In each part, the characteristics of the sector relevant to GHG formation (or removal) are described and the GHG emissions are quantified by pollutant and sector category (e.g., transportation mode, type of industrial process). The supporting data for the figures are presented in Appendix A.

Emissions of a GHG are commonly expressed in terms of "tons of carbon dioxide equivalent" (TCDE) on an annual basis, obtained by multiplying the actual tons of emissions by the GHG's "global warming potential" (GWP). Global warming potential is the ratio of global warming, or radiative forcing from one kilogram of a greenhouse gas to one kilogram of CO_2 over a period of time. Global warming potentials, actual emissions, and emissions in TCDE for the primary GHGs are listed in Table ES-1. Figure ES-1 is a graphical representation of the data in Table ES-1.

Carbon dioxide is largely a product of combustion and respiration. Over 99% of CO_2 emissions in New Hampshire originate from fossil fuel consumption (see Energy Use Sector). Activities within the Industrial Processes (use of soda ash and calcium carbonate) and Agriculture Sectors (carbonate-based soil neutralizers and crop waste burning) are responsible for the remaining one percent of CO_2 emissions in New Hampshire. Forested areas, accounted for in the Land Use Sector, act as carbon "sinks" through photosynthesis, and reduce net GHG emissions. As Figure ES-1 illustrates, CO_2 emissions dominate New Hampshire's GHG inventory.

Nitrous oxide is generated mainly from the internal combustion of fuels, and thus the transportation category of the Energy Use Sector is the primary source of N_2O. Another contributor is the use of nitrogen-based fertilizer for soil management within the Agriculture Sector.

Methane emissions result from several activities in the Energy Use, Waste Management and Agriculture Sectors. Landfills are the most significant source of methane in New Hampshire. Other categories, which contribute to methane emissions, include all categories in the Energy Sector (including leaks in natural gas distribution system), wastewater, enteric fermentation, and agricultural burning. Individual sources of methane emissions are detailed in Parts I-V.

C. Summary of New Hampshire's Greenhouse Gas Emissions Inventory

Total gross greenhouse gas emissions for the State of New Hampshire in 1993 were

approximately 17,777,610 tons of carbon dioxide equivalent (TCDE). Net emissions were estimated at 12,888,353 TCDE. In order to calculate net carbon dioxide emissions, stored carbon dioxide amounts were subtracted from gross carbon dioxide emissions. Stored carbon, also known as carbon sequestering, is the process of carbon uptake and accumulation preventing gaseous carbon from moving into the atmosphere.

Table ES-1 breaks down greenhouse gas emissions totals by greenhouse gas type. As can be seen, carbon dioxide emissions, responsible for approximately 89 percent of total emissions, are by far the biggest source of greenhouse gas emissions in New Hampshire. Methane emissions represent roughly 10 percent of the total while nitrous oxide is responsible for approximately 1 percent of total greenhouse gas emissions. The dominant role of carbon dioxide in New Hampshire greenhouse gas emissions is graphically shown in Figure ES-1.

Emissions of greenhouse gases were divided into five energy use sectors as seen in Table ES-2. Among these five sectors, energy use is the predominate producer of approximately 93 of total gross emissions. Waste management, mostly from methane emissions from solid waste landfills, contributes approximately 6 percent of total gross emissions. Industrial Processes and Agriculture are responsible for the remaining 1 percent of emissions. Land Use, due to carbon sequestering mostly from forest regeneration, acts in total to reduce carbon dioxide emissions. Gross carbon dioxide emissions were reduced by 28 percent (see Figure ES-2).

Current and future greenhouse gas emissions and the ensuing climate change that may occur have the potential to severely impact New Hampshire's ecosystems and economy. New Hampshire's "Greenhouse Gas Inventory" is intended to be one of many resources from which an action plan can be developed to steer New Hampshire on a proactive course to mitigate our contribution to "global warming".

New Hampshire Greenhouse Gas
Emissions Inventory (1993)
Breakdown by Greenhouse Gas
TCDE - Tons Carbon Dioxide Equivalent

Greenhouse Gas	Global Warming Potential (GWP)		Gross Emissions (Tons)	Gross Emissions (TCDE)		Net Emissions (Tons)	Net Emissions (TCDE)
Carbon Dioxide	1		16,323,823	16,323,823		11,434,566	11,434,566
Methane	24.5		51,258	1,255,827		51,258	1,255,827
Nitrous Oxide	320		619	197,960		619	197,960
			TOTAL	**17,777,610**		TOTAL	**12,888,353**

Table ES-1

Emissions Inventory (1993)
Breakdown by Primary Sectors
TCDE - Tons Carbon Dioxide Equivalent

Sector	Category	Carbon Dioxide Emissions (Tons)	Carbon Dioxide Emissions (TCDE)	Methane Emissions (Tons)	Methane Emissions (TCDE)	Nitrous Oxide Emissions (Tons)	Nitrous Oxide Emissions (TCDE)	Category Total (TCDE)	Sector Total (TCDE)
Energy Use	Fossil Fuel Combustion	16,251,616	16,251,616	1,265	30,984	598	191,516		
	Biomass Fuel	0	0	482	11,809	0	0	16,474,115	
	Consumption	0	0	1,683	41,234	0	0	11,809 41,234	
		---	---	---	---	---	---		
	Natural Gas Pipeline	**16,251,616**	**16,251,616**	**3,430**	**84,026**	598	**191,516**		

	Leaks								**16,527,158**
Industrial Processes	Limestone Soda Ash	67,210 2,729 ---------- **69,939**	67,210 2,729 ---------- **69,939**	0 0 -------- 0	0 0 -------- 0	0 0 -------- 0	0 0 -------- 0	67,210 2,729	**69,939**
Waste Management	Solid Waste Landfill Wastewater Treatment	0 0 -------- 0	0 0 -------- 0	42,853 295 -------- 43,148	1,049,889 7,230 -------- 1,057,119	0 0 -------- 0	0 0 -------- 0	1,049,889 7,230	**1,057,119**
Agriculture	Enteric Fermentation Manure Mangement Soils Management Crop Waste Burning	0 0 2,269 0 ------- 2,269	0 0 2,269 0 ------- 2,269	3,824 856 0 0 ------- 4,681	93,693 20,978 0 10 -------- 114,681	0 0 20 0.06 -------- 20	0 0 6,424 21 -------- 6.444	93,693 20,978 8,692 31	**123,394**
	GROSS EMISSIONS	16,323,823	16,323,823	51,258	1,255,827	619	197,960	TOTAL	17,777,610
Land Use	Forest and Woody Biomass Stock Forest and Grass Land Conversion Abandoned Lands	-5,013,880 137,041 -12,418 -------- **-4,889,257**	-5,013,880 137,041 -12,418 -------- **-4,889,257**	0 0 0 -------- 0	0 0 0 -------- 0	0 0 0 -------- 0	0 0 0 -------- 0	-5,013,880 137,041 -12,418	**-4,889,257**
	NET EMISSIONS	11,434,566	11,434,566	51,258	1,255,827	619	197,960	TOTAL	12,888,353

Table ES-2

Introduction

A. The Greenhouse Effect

The "greenhouse effect" is the commonly accepted term for the process by which so-called "greenhouse gases" (GHGs) re-radiate the sun's thermal energy back into the earth's atmosphere, thus warming it. The sun's energy arrives in the earth's atmosphere in the form of ultraviolet light. Ultraviolet light has a short wavelength, which allows it to penetrate the gases present in the atmosphere. Most of the ultraviolet light is absorbed by the earth. A portion of the energy, however, is reflected in the form of infrared light. The wavelength of infrared light is significantly longer than that of ultraviolet light and, consequently, cannot radiate through the greenhouse gases present in the earth's atmosphere. Thus, the energy from this infrared light is retained within the lower atmosphere, resulting in an increase of surface temperature. This phenomenon is analogous to the common greenhouse used for growing plants, which is designed to absorb and retain solar energy to enhance photosynthesis.

A Global Warming Index (GWP) index was created to translate the level of emissions of various gases into a common metric in order to compare the climate forcing effects without directly calculating the changes in atmospheric concentrations (Lashof and Tirpak, 1990). This allows comparison of the potential of different greenhouse gases to warm on a level playing field. The GWP is defined as the ratio of global warming, or radiative forcing (both direct and indirect), from one kilogram of a greenhouse gas to one kilogram of carbon dioxide over a period of time.

Greenhouse gases identified to date include carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), water vapor, ozone (O_3), fluorocarbons (CFCs, HCFCs, HFCs, PFCs) and other halocarbons. To date, only the GWPs of CO_2, CH_4 and N_2O have been scientifically quantified, and so New Hampshire's GHG emissions inventory, like the national inventory, focuses on the these three primary GHGs. Water vapor, although a significant contributor to global warming, occurs in such great abundance as a result of naturally occurring physical, chemical and biological processes, that it is regarded as an uncontrollable GHG and is not normally inventoried. Ozone is a secondary pollutant resulting from a complex chain of photochemical reactions between (primarily) non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), and oxides of nitrogen (NOX), in the presence of sunlight and heat. Its effects are highly variable and extremely difficult to quantify and therefore ozone is not inventoried here. Fluorocarbons and halocarbons, although believed to have significant GWPs and almost entirely of anthropogenic origin, are largely being phased out as a result of an international agreement reached under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) and are not inventoried.

Once, concentrations of GHG's were thought to remain constant over many centuries. Currently, the preponderance of evidence suggests that the concentrations of GHGs in the earth's atmosphere, which were believed to remain constant over many centuries, have

recently exhibited marked increases due to anthropogenic activities. Hence, the need for the various states and other governing entities to compile inventory data on GHGs and to propose action plans for reducing GHG emissions is widely recognized.

Carbon dioxide is by far the most prominent of the greenhouse gases in terms of total emissions; it is a by-product of combustion, especially the burning of high carbon fossil fuels. Trees and other vegetation consume carbon dioxide as part of their life cycle, referred to in this context as carbon sequestering. Through carbon sequestering, vegetation plays an important role in reducing the concentration of carbon dioxide in the atmosphere.
The two other primary GHGs, methane and nitrous oxides, are emitted in far lower quantities than carbon dioxide, however the GWPs of these GHGs far exceed that of carbon dioxide and so their overall contribution to the inventory is significant (see Figure ES-1).

B. Objectives of New Hampshire's GHG Inventory

The purpose of compiling this inventory is to identify and quantify the sources of GHG emissions in New Hampshire for the analysis year 1993. This information will be the basis for developing a State Action Plan that will establish GHG emissions targets and will aid in the formulation of a strategy to meet these targets.

New Hampshire is conducting this inventory as part of an effort to quantify GHG emissions nationwide. This inventory evaluates state-specific conditions in terms of such variables as fuel consumption, forestry, agriculture, and landfills. The intent of this inventory report is three-fold:

- Assist the key federal agencies, such as the U.S. Environmental Protection Agency and the Department of Energy, as well as national and international panels such as the Intergovernmental Panel on Climate Change (IPCC), in developing strategies for coordinated efforts to reduce anthropogenic contributions to the greenhouse effect.

- Promote a greater awareness among New Hampshire's citizens and its key economic sectors of the state's own contribution to global warming and encourage public input.

- Assist the state in its own planning so as to minimize New Hampshire's contribution to the greenhouse effect without placing excessive or inequitable burdens on its industry or citizens.

C. Methodology

New Hampshire's greenhouse gas inventory was performed using the U.S. Environmental Protection Agency guidance document entitled State Workbook Methodology for Estimating Greenhouse Gas Emissions, Second Edition, as the primary reference. Other references and sources are documented in Appendix A.

D. Inventory Report Organization

The body of this publication is divided into five parts, or activity "sectors": energy use, industrial processes, waste management, agriculture, and land use. Parts I-IV identify and quantify the sources of GHG emissions. Part V, land use, quantifies the net "sinks"

associated with forested land (carbon sequestering) and their impact on reducing carbon dioxide emissions. Each part is supported by tables of computation summaries and data sources in Appendix A. Appendix B is a glossary of greenhouse gas related terms.

Part I

Energy Use

A. Overview of Energy Use Categories

Prior to the industrial age, the sources of energy for transportation, agriculture, manufacturing, and heating/cooling were man, animals and farm/forest products. The tapping of fossil fuels to operate engines, power plants, commercial and industrial equipment and consumer devices, during the past two centuries has profoundly altered lifestyles. According to the theory of the "enhanced" greenhouse effect or global warming, the earth's climate has also been affected. The evidence to date of a statistical correlation between lifestyle and climate changes has been a foundation for considering fossil fuel energy consumption as a major source of greenhouse gases and for developing scientific models to examine this hypothesis.

There are three categories of GHG emissions attributable to the Energy Use Sector in New Hampshire that are documented in this inventory:

1. Fossil Fuel Consumption
2. Biomass Fuel Consumption
3. Natural Gas Pipeline Leaks

Table I-1 lists actual emissions and the TCDEs of the primary GHGs (CO_2, CH_4, N_2O) for the three energy use sector categories. Fossil fuel consumption is further broken down into the subcategories as described below. Greenhouse gas emissions computations for the energy use sector categories and subcategories are given in Appendix Tables A-I.1a through A-I.1c, A-I.2, and A-I.3.

B. Emissions from Fossil Fuel Consumption

As noted previously, the combustion of fossil fuels is the activity responsible for much of New Hampshire's GHG emissions. Oil and coal (and their derivatives) are carbon-based fuels that humans have come to rely on heavily for transportation and the production of electricity. The fossil fuel consumption category is further divided into five subcategories: residential heating and cooling, commercial activity, industrial activity, transportation and electric utilities.

All three primary GHGs are emitted because of fossil fuel combustion, although CO_2 is by far the highest contributor to New Hampshire's greenhouse gas emissions. This GHG is produced when the carbon in fuel is oxidized via the combustion process, whereby the heat

of combustion atomizes the carbon-bearing molecules. The carbon atoms eventually combine chemically with the oxygen in the air to generate CO_2, water vapor and CO. The carbon content and the nature of the transformation process for the various fossil fuel classes (solids, liquids and gases) vary widely. For example, the average carbon content of coal is nearly twice that of natural gas. CO_2 emission factors for the various fuels will depend on the fuel class and type combusted, and the efficiency of the combustion device.

It should be noted that New Hampshire is a net exporter of electricity. Domestic demand for electricity is satisfied by New Hampshire utilities power production, a small surplus then being exported to other states. Thus, it was not necessary to exclude imported electricity from any calculations made of greenhouse gas emissions.

Methane (CH_4) is also a by-product of combustion of fossil fuels and emissions are largely a function of the efficiency of the device. In vehicles, CH_4 emissions are highest when air-fuel mixtures are "rich", in other words with less oxygen than required for complete combustion. In well-tuned spark ignition engines, this occurs especially during idle, low speed and cold start conditions. The overall contribution of methane from the fossil fuel consumption category to New Hampshire's total methane emissions is relatively minor.

The transportation subcategory is the primary source of nitrous oxide (N_2O) in New Hampshire. N_2O is generated during the internal combustion of fuel, however it is removed rapidly in the post-flame gas by the reaction between N_2O and hydrogen. The N_2O forming process occurs during catalytic aftertreatment of exhaust gases. N_2O is produced during the reaction of nitrogen oxide (NO) and ammonia (NH_3) over the platinum in the catalytic converter. The output of N_2O from the catalyst is highly temperature dependent with the highest levels experienced during the cold-start phase of vehicle operation.

Carbon sequestering, the uptake and storing of carbon, occurs in two industrial areas, the paving of roads, characterized as asphalt and road oil, and, in the makeup of industrial lubricants. Stored carbon amounts are subtracted from gross carbon dioxide emission amounts in the asphalt and road oil sector and the industrial lubricant sector producing net carbon dioxide emission amounts. The final net emission amounts are detailed in Appendix Table A-I.1c.

C. Emissions from Biomass Fuel Consumption

Biomass fuel use in New Hampshire consists primarily of wood burning for production of electricity and residential heating. CO_2 is a product of the combustion of biomass fuels, however this inventory does not account for CO_2 emissions from this category. During the process of photosynthesis, trees and plants "sequester" carbon through the consumption of CO_2. The amount of CO_2 produced during combustion of biomass fuels is assumed equivalent to that amount that re-enters the biomass component during photosynthesis.

Methane emissions are the only GHG emissions accounted for from the biomass fuel consumption category. During the flame stage of combustion, oxygen as CO_2 is produced. In the smoldering phase, when less oxygen is available, methane and other non-CO_2 gases are produced. The process of calculating the contributions of methane from biomass fuel combustion is summarized in Appendix Table A-I.2.

D. Emissions from Natural Gas Pipeline Leaks

Natural gas is composed primarily of methane (CH_4). Methane emissions from the processing, transportation and distribution of natural gas are quantified in this inventory. The major sources are fugitive emissions, and deliberate releases from pneumatic devices and process vents. Other less significant sources include combustion of natural gas in gas turbines, internal combustion engines, etc., routine maintenance, and system upsets and accidents.

Limited data exist relative to emission factors for fugitive emissions from the processing, transportation and distribution of natural gas. Estimates for methane emissions from this category are derived from the overall natural gas consumed within New Hampshire (see Appendix Table A-I.3).

E. Conclusions

The energy use sector contributes 16,527,158 TCDE to New Hampshire's GHG inventory, and is by far the most significant of the five sectors. Table I-1 illustrates that, of the three categories within the energy use sector, fossil fuel combustion is the most prominent. The transportation and electric utilities subcategories combined account for about two thirds of the carbon dioxide emissions not only in the fossil fuel category, but statewide, a further indication of the prominence of these subcategories on the overall GHG inventory.

Of the total nitrous oxide emissions contribute 191,516 TCDE. Transportation is the major source of these emissions, vehicles equipped with catalytic converters, comprising the single largest source. Methane emissions from the energy use sector total 84,026 TCDE.

Table I-1
New Hampshire Greenhouse Gas
Emissions Inventory (1993)
Energy Use Sector

	CO2 Emissions (tons CO2)	CO2 Emissions GWP = 1.0 (TCDE)	CH4 Emissions (tons CH4)	CH4 Emissions GWP = 24.5 (TCDE)	N2O Emissions (tons N2O)	N2O Emissions GWP = 320.0 (TCDE)	Category Total Emissions (TCDE)
FOSSIL FUEL CONSUMPTION							
Residential	2,666,469	2,666,469	146	3,576	0	0	2,670,045
Commercial	1,182,924	1,182,924	22	539	0.1	32	1,183,495
Industrial Activity	1,580,222	1,580,222	59	1,449	1	160	1,581,831
Transportation	5,959,023	5,959,023	1,004	24,591	598	191,324	6,174,938
Electric Utilities	4,862,978	4,862,978	34	829	0	0	4,863,807
subtotals	**16,251,616**	**16,251,616**	**1,265**	**30,984**	**598**	**191,516**	**16,474,115**
BIOFUEL CONSUMPTION*							
Residential	0	0	266	6,519	0	0	6,519
Industrial	0	0	54	1,314	0	0	1,314
Utilities	0	0	162	3,964	0	0	3,964
Governmental	0	0	0.5	12	0	0	12
subtotals	**0**	**0**	**482**	**11,809**	**0**	**0**	**11,809**

NATURAL GAS PIPELINE LEAKS	0	0	1,683	41,234	0	0	41,234
	(CO2 tons)	**(CO2 TCDE)**	**(CH4 tons)**	**(CH4 TCDE)**	**(N2O tons)**	**(N2O TCDE)**	**NET (TCDE)**
TOTAL	**16,251,616**	**16,251,616**	**3,430**	**84,026**	**598**	**191,516**	**16,527,158**
* Carbon Dioxide emissions for biofuels are not included in GHG inventory							

Part II

Industrial Processes

A. Overview

Industrial processes that are the principal emitters of greenhouse gases are the production of cement, aluminum, nitric and adipic acid, lime, soda ash and carbon dioxide. The primary GHG emission from their production is carbon dioxide. These processes generally rely on accesability of raw materials and energy. Based on the latest available statewide data (1993), New Hampshire's industries do not currently perform any of these primary industrial processes. The use of soda ash (sodium carbonate - $NaCO_3$) and limestone (calcium carbonate - $CaCO_3$) in industrial processes has the potential to emit carbon dioxide, although at a lower rate than would be associated with the actual production of these materials.

The Industrial Processes Sector is not divided into categories. Instead, it is broken down into total limestone and total soda ash use in New Hampshire as seen in Table II-1. Further detail on the consumption of soda ash and limestone in New Hampshire and computation of the resulting CO_2 emissions is given in Appendix Table A-II.1.

B. Emissions from Industrial Processes

Limestone is a basic raw material used by a wide variety of industries, including the manufacturing of paper products. Paper mills typically utilize a limekiln where a limestone ($CaCO_3$) solution is heated to generate calcined lime (CaO) for eventual use as a caustisizing agent to produce sodium hydroxide (NaOH). Sodium hydroxide is one of the principal agents in the breakdown of pulpwood in the paper manufacturing process. The reaction in the limekiln generates carbon dioxide as per the following equation:

$$CaCO_3 + \text{heat} \;®\; CaO + CO_2$$

In New Hampshire, paper manufacturing produces most of the GHG emissions from the Industrial Processes Sector. Relatively small amounts of soda ash are used in New Hampshire by industries manufacturing paper, textiles and glass, and by industry and municipalities for water treatment.

C. Conclusions

Industrial processes in New Hampshire are characterized by end use of GHG-producing chemicals, rather than initial manufacture of such substances. Carbon dioxide is the only major GHG emitted in significant quantities, totaling 69,939 TCDE, generated primarily by the state's paper mills. The manufacture of textiles and glass, and the treatment public and private water systems are the only other sources of GHG emissions from the Industrial Processes Sector.

Table II-1
New Hampshire Greenhouse
Gas Emissions Inventory (1993)
Industrial Processes Sector

	CO2 Emissions (tons CO2)	CO2 Emissions GWP = 1.0 (TCDE)	CH4 Emissions (tons CH4)	CH4 Emissions GWP = 24.5 (TCDE)	N2O Emissions (tons N2O)	N2O Emissions GWP = 320.0 (TCDE)	Category Total (TCDE)
LIMESTONE (CaCO3)							
Paper mills	67,210	67,210	0	0	0	0	67,210
SODA ASH (NaCO3)							
Paper mills	2,636	2,636	0	0	0	0	2,636
Textiles, glass, misc.	1	1	0	0	0	0	1
Water treatment	93	93	0	0	0	0	93
subtotals	**2,729**	**2,729**					**2,729**
	(CO2 tons)	**(CO2 TCDE)**	**(CH4 tons)**	**(CH4 TCDE)**	**(N2O tons)**	**(N2O TCDE)**	**NET (TCDE)**
TOTAL	69,939	69,939	0	0	0	0	69,939

Greenhouse Gas Inventory

Part III

Waste Management

A. Overview of Waste Management Categories

The management of waste generated by the activities of man has been a public health issue and a nuisance for centuries. The major issue is how to economically dispose of the high volume of waste generated by the masses? Emissions of greenhouse gases are produced during the collection and disposal of large volumes of waste in a central location.

Most of New Hampshire's solid waste is landfilled. A portion of New Hampshire's municipal solid waste is dedicated to fuel "trash to energy" electric generating plants, however emissions from such plants are not accounted for in this inventory. The only accounted for GHG generated by the Waste Management Sector is methane.

There are two categories of GHG emissions attributable to the Waste Management Sector in New Hampshire that are documented in this inventory:

1. Solid Waste Landfills
2. Wastewater Treatment

Table III-1 lists the actual emissions and the TCDEs of methane emissions from the two waste management categories. Greenhouse gas emissions computations for this sector are given in Appendix Tables A-III.1 and A-III.2.

B. Solid Waste Landfills

Methane and carbon dioxide are produced in the anaerobic (without oxygen) decomposition of organic waste in landfills by methanogenic bacteria. Since the CO_2 is generated primarily from the decomposition of organic materials derived from biomass sources, methane is the only GHG accounted for from Solid Waste Landfills.

Numerous factors affect the amount of methane produced and these can be broken down into factors related to management practices and physical factors. The density and particle size of the refuse and the portion of waste that is landfilled are factors related to management practices. The waste composition, moisture content, leachate pH, nutrients and temperature of the landfill are physical factors.

For the purpose of this inventory, small landfills (those receiving less than 1.1 million tons of waste per year) and large landfills (those receiving more than 1.1 million tons of waste per year) are considered separately. Smaller landfills generally produce less methane because the density of the landfill material is lower. The greater density of the waste in larger

landfills increases its ability to absorb and leads to more methane production per unit volume. In the northeast, it is assumed that 89% of the waste landfilled is done so at large landfills. Appendix Table A-III.1 provides the computation for methane emitted at landfills in New Hampshire.

C. Wastewater Treatment

Wastewater can be treated using aerobic and anaerobic technologies. Methane is produced when wastewater is treated anaerobically. It is estimated that 91% of the treated wastewater in New Hampshire is treated aerobically. The remaining 9% of influent wastewater is treated anaerobically. Three municipalities and one industrial facility reported that their wastewater was treated with an anaerobic digester to decompose the solid matter, with an effort made to recover most of the methane emitted during the digestion process. Approximately 46% of the methane released from wastewater treatment in New Hampshire is recovered. Appendix Table A-III.2 provides the computation for net methane emitted from the anaerobic treatment of wastewater.

D. Conclusions

Methane is the only GHG accounted from New Hampshire's waste disposal activities, and over 99% of it results from landfilling of solid waste. Methane emissions from the Waste Management Sector total 1,057,119 TCDE, or roughly 8.2% of the net GHG emissions in New Hampshire in 1993 (see Table ES-2).

Table III-1
New Hampshire Greenhouse Gas
Emissions Inventory (1993)
Waste Management Sector

	CO2 Emissions (tons CO2)	CO2 Emissions GWP = 1.0 (TCDE)	CH4 Emissions (tons CH4)	CH4 Emissions GWP = 24.5 (TCDE)	N2O Emissions (tons N2O)	N2O Emissions GWP = 320.0 (TCDE)	Category Total (TCDE)
Solid Waste Landfills							
Small Landfills	0	0	533	13,052	0	0	13,052
Large Landfills	0	0	42319.865	1,036,837	0	0	1,036,837
subtotals			**42,853**	**1,049,889**			**1,049,889**
Wastewater Treatment							
	0	0	295	7,230	0	0	7,230
	(CO2 tons)	**(CO2 TCDE)**	**(CH4 tons)**	**(CH4 TCDE)**	**(N2O tons)**	**(N2O TCDE)**	**NET (TCDE)**
TOTAL	0	0	43,148	1,057,119	0	0	1,057,119

Greenhouse Gas Inventory

Part IV

Agriculture Sector

A. Overview

Agriculture, the practice of horticulture and husbandry, has undergone significant transformations in New Hampshire over the past several decades. Although New Hampshire has become one of the least agricultural states in the nation in terms of percentage of land devoted to livestock and cash crops, the total quantifiable GHG emissions from this activity is nearly double that of the industrial sector.

The four principal agricultural activity categories that generate greenhouse gases are:

1. Enteric fermentation
2. Manure management
3. Soils management
4. Crop waste burning

Table IV-1 lists the emissions in tons and TCDE for each of the primary GHGs for the four categories listed above. Greenhouse gas emissions computations for the Agriculture Sector categories are given in Appendix Tables A-IV.1, A-IV.2, A-IV.3 and A-IV.4.

B. Enteric Fermentation Emissions

Methane is produced as part of the normal digestive processes of ruminant animals, referred to as enteric fermentation. Ruminant animals have large fore-stomachs, or rumens, within which microbial fermentation breaks down feed into soluble products that can be utilized by the animals. Methane is produced in the rumen by bacteria as a by-product of the fermentation process.

Many domesticated animals are ruminant animals. The most significant in terms of methane production are cattle. Although wild ruminant animals, such as deer, also produce methane, they are considered natural sources and are not accounted for in this inventory. Several factors affect the methane production in ruminant animals including the physical and chemical characteristics of the feed, the feeding level and schedule, the use of feed additives to promote production efficiency, and the activity and health of the animal. Of these factors, the feed characteristics and level have the most influence.

This inventory includes estimates of methane emissions as a result of enteric fermentation from sheep, goats, pigs, horses, dairy cattle and beef cattle. Appendix Table A-IV.1 provides further detail on the computation of methane emissions from these domesticated animal subcategories.

C. Manure Management Emissions

Manure decomposition is a process in which microorganisms derive energy and material for cellular growth by metabolizing organic material in the manure. When decomposition occurs anaerobically, methane is a product of the process. As is the case with enteric fermentation emissions, the most significant source of manure management emissions is cattle.

In general, livestock manure is highly conducive to methane generation due to its high organic content and the presence of useful bacteria. A greater energy content and better digestibility of the feed results in a greater methane producing capacity in the resulting manure. Feedlot cattle eating a high-energy grain diet produce highly biodegradable manure with a high methane producing capacity. Range eating cattle eating a low energy forage diet produce a less biodegradable manure with a lower methane producing capacity.

This inventory includes estimates of methane emissions from manure management for sheep, goats, poultry, turkeys, pigs, horses, dairy cattle and beef cattle. Appendix Table A-IV.2 provides further detail on the computation of methane emissions from these domesticated animal subcategories.

D. Soil Management Emissions

Nitrous oxide (N_2O) is produced naturally in soils through the microbial processes of denitrification and nitrification. A number of anthropogenic activities add nitrogen to soils, ultimately increasing the amount of N_2O emitted. These activities include application of fertilizers, atmospheric deposition, and cultivation of nitrogen-fixing crops. Fertilizer use is the most significant source of nitrous oxide emissions.

To generate the most representative emissions data for the base year (1993), an average of fertilizer use for the three years 1992, 1993, and 1994 was computed. Appendix Table A-IV.3 provides detail on the computation of N_2O emissions from fertilizer use in New Hampshire.

E. Emissions from the Burning of Agricultural Crop Waste

Burning of lawns, leaf litter and crop residue was practiced more in the past (prior to the nearly universal adoption of open burning prohibitions) than today. Crop residue burning is a net source of GHG emissions, specifically CH_4 and N_2O, which are released during combustion. Currently, the only reported agriculture related burning in New Hampshire is that of (wild) low bush blueberry crops. Each stand is burned off every two or three years to reduce competition from other plants, to prune the current crop, and to return nutrients to the soil. This activity produces an insignificant amount of GHG emissions in New Hampshire. Appendix Table A-IV.4 provides detail on the computation of GHG emissions from the crop

waste-burning category.

F. Conclusions

Although agriculture no longer plays a significant role in New Hampshire's overall economy, this sector still generates roughly twice the GHG emissions than industrial processes that are not associated with fuel burning. As illustrated by Table IV-1, the greatest share of agriculturally generated GHGs is attributable to the methane emissions because of enteric fermentation digestion. The overall contribution of the Agriculture Sector to New Hampshire's net GHG inventory is approximately one percent.

Table IV-1
New Hampshire Greenhouse Gas
Emissions Inventory (1993)
Agriculture Use Sector

	CO2 Emissions (tons CO2)	CO2 Emissions GWP = 1.0 (TCDE)	CH4 Emissions (tons CH4)	CH4 Emissions GWP = 24.5 (TCDE)	N2O Emissions (tons N2O)	N2O Emissions GWP = 320.0 (TCDE)	Category Total (TCDE)
Enteric Fermentation							
Dairy Cattle	0	0	3,056	74,881	0	0	74,881
Beef Catle	0	0	426	10,443	0	0	10,443
Other Domesticated Animals	0	0	342	8,369	0	0	8,369
subtotals			**3,824**	**93,693**			**93,693**
Manure Management							
Dairy Cattle	0	0	733	17,969	0	0	17,969
Beef Catle	0	0	8	194	0	0	194
Other Domesticated Animals	0	0	115	2,814	0	0	2,814
subtotals			**856**	**20,978**			**20,978**
Soils Management							
Fertilizer	0	0	0	0	20	6,424	6,424
Limiing Agent	2269	2269	0	0	0	0	2,269
subtotals	**2269**	**2269**			**20**	**6424**	**8693**
Crop Waste Burning	0	0	0.4	10	0.06	21	31
	(CO2 tons)	**(CO2 TCDE)**	**(CH4 tons)**	**(CH4 TCDE)**	**(N2O tons)**	**(N2O TCDE)**	**NET (TCDE)**
TOTAL	2,269	2,269	4,681	114,681	20	6,444	123,394

Greenhouse Gas Inventory

Part V

Land Use

A. Overview

The biosphere emits and absorbs a wide variety of carbon and nitrogen trace gases. When humans use and alter the biosphere though forest management and land-use change activities, such as clearing an area of forest to create cropland, restocking a logged forest, draining a wetland, or allowing a pasture to revert to grassland, the natural balance of these trace gas emissions and uptake is altered and their atmospheric concentrations adjust. As a result of biological processes (e.g., growth and mortality) and anthropogenic activities (e.g., harvesting, thinning, and other removals), carbon is continuously cycled through these ecosystem components, as well as between the forest ecosystem and the atmosphere. For example, the growth of trees results in the uptake of carbon from the atmosphere and storage in living trees. As these trees age, they continue to accumulate carbon until they reach maturity, at which point they are relatively constant carbon stores. As trees die and otherwise deposit litter and debris on the forest floor, decay processes will release carbon to the atmosphere and also increase soil carbon. The net change in forest carbon is the change in the total net amount of carbon stored in each of these pools (i.e., in each ecosystem component) over time.

In the mid-19th century, approximately half of New Hampshire's 5.9 million acres was forested. Overall, the forested area has increased substantially as abandoned farms became reforested, so that by 1992, it was estimated that approximately 4.7 million acres, or 79% of the state's total area, was forested.

To determine net GHG emissions from the Land Use sector in New Hampshire, the sector was broken into four principle categories:

1. Changes in Forest and Woody Biomass Stock
2. Forest and Grassland Conversion
3. Abandoned Lands
4. Natural Methane Production in Wetlands

Table V-1 lists the carbon uptake and carbon released from each category, along with the net GHG emissions by category and total for the Land Use sector. The categories are described below.

B. Changes in Forest and Woody Biomass Stock

This category is very broad and includes a wide variety of land-uses and management practices. It focuses heavily on changes in forests, however other types of biomass (e.g., trees in developed areas) are included. The most important effects of human interaction with existing forests are considered in this category, including commercial management and logging for forest products, the harvest of fuelwood, and the establishment of forest plantations as well as planting trees in urban, suburban, or other non-forest locations.

Carbon is sequestered by growing vegetation through the process of photosynthesis. Carbon is released when forested areas are logged. The actual release does not occur until the forest products have been combusted or decayed, however the release is accounted for in the year the harvesting takes place. This means that this category serves to reduce the net GHG emissions in New Hampshire. In New Hampshire, the net effect of the forested areas is a carbon "sink".

Appendix Table A-V.1 details the computations for carbon uptake and release from changes in forest and woody biomass stock.

C. Forest and Grassland Conversion

This category includes the conversion of existing forest and grasslands to other land uses, including agriculture, highways, urban development, etc. As with all categories of forest management and land-use change activity, it is necessary to determine net carbon flux from biomass loss.

Forest and grassland conversion also results in carbon dioxide emissions through soil disturbance and oxidation of soil organic matter, particularly when the conversion is to cultivated lands or urban development. This long-term process may continue for many years after the land-use change occurs.

Appendix Table A-V.2 details the computations for aboveground and belowground carbon release from forest and grassland conversions.

D. Abandoned Lands

Lands that had been managed previously (i.e., croplands, pasture) and that are abandoned and allowed to regrow naturally, without any human interference, can reaccumulate significant amounts of carbon in their biomass and soils. This category includes the lands that are regrowing naturally into their prior grassland or forest conditions.

Appendix Table A-V.3 details the computations for aboveground and belowground carbon uptake from abandoned lands.

E. Natural Methane Production in Wetlands

In addition to forest activity, New Hampshire's 710,000 acres of wetlands are also continuously sequestering carbon and emitting methane. These totals are computed for New Hampshire but are not included in this inventory because the process is a natural state of flux. Appendix Table A-V.4 details the computations for GHG emissions relative to wetlands.

F. Conclusions

Unlike the other four sectors, forest management and utilization has the potential to both release and deplete carbon dioxide emissions; hence, it is necessary to report the inventory for this sector in terms of net emissions. Carbon depletion (or uptake), which is almost entirely attributable to current forest growth, exceeds carbon releases (primarily from lumber and cordwood) by over 1.3 million tons, resulting in a net CO_2 depletion of nearly 5 million TCDE. Appendix Table A-V.5 tallies the carbon uptake and release for the Land Use Sector.

Table V-1
New Hampshire Greenhouse Gas
Emissions Inventory (1993)
Land Use Sector

	Carbon Uptake (tons Carbon)	Carbon Released (tons Carbon)	Net CO2 Emissions (tons CO2)	Net CO2 Emissions GWP = 1.0 (TCDE)
FOREST and WOODY BIOMASS STOCK				
Forested Land	2,582,303	1,426,511	4,273,903	-4,237,903
Developed Land	211,630		-775,976	-775,976
subtotals	**2,793,933**	**1,426,511**	**-5,013,880**	**-5,013,880**
FOREST and GRASSLAND CONVERSION				
Above Ground Carbon	0	21,534	78,958	78,958
Below Ground Carbon	0	15,841	58,083	58,083
subtotals	**0**	**37,375**	**137,041**	**137,041**
ABANDONED LANDS				
Above Ground Carbon	1647	0	-6,038	-6,038
Below Ground Carbon	1740	0	-6,380	-6,380
subtotals	**3,387**	**0**	**-12,418**	**-12,418**
	(Carbon tons)	**(Carbon tons)**	**(CO2 tons)**	**(CO2 TCDE)**
TOTAL	2,797,320	1,463,886	-4,889,257	-4,889,257

APPENDIX A

Data, Data Sources and Calculations

Table A-I.1a Energy Use Sector - Fossil Fuel Consumption Category

SUBCATEGORY/FUEL	A Fuel Consumption (MMBtu)	B Carbon Content Coefficient (lbs C/MMBtu)	C Total Carbon (tons C)	D Total Carbon Oxidized (tons C)	E CO2 Emissions (44/12) (tons CO2)	F CO2 Emissions GWP = 1.0 (TCDE)	G CH4 Emission Factor (lbs/MMBtu)	H CH4 Emissions (tons CH4)	I CH4 Emissions GWP = 24.5 (TCDE)	J N2O Emission Factor (lbs/MMBtu)	K N2O Emissions (tons N2O)	L N2O Emissions GWP = 320.0 (TCDE)
RESIDENTIAL												
Distillate	22200000	44	488400	483516	1772892	1772892	0.011	122.1	2991.45	N/A	0	0
Kerosene	2000000	43.5	43500	43065	157905	157905	0.011	11	269.5	N/A	0	0
LPG	5300000	37.8	100170	99168.3	363617.1	363617.1	0.0024	6.36	155.82	N/A	0	0
Anthracite Coal	100000	62.1	3105	3073.95	11271.15	11271.15	N/A	0	0	N/A	0	0
Natural Gas	6200000	31.9	98890	98395.55	360783.6833	360783.6833	0.0021	6.51	159.495	N/A	0	0
subtotals	**35800000**				**2666468.933**	**2666468.933**		**145.97**	**3576.265**		**0**	**0**
COMMERCIAL												
Distillate	6500000	44	143000	141570	519090	519090	0.0013	4.225	103.5125	N/A	0	0
Kerosene	200000	43.5	4350	4306.5	15790.5	15790.5	0.0013	0.13	3.185	N/A	0	0
LPG	900000	37.8	17010	16839.9	61746.3	61746.3	0.0025	1.125	27.5625	N/A	0	0
Motor Gasoline	100000	42.8	2140	2118.6	7768.2	7768.2	0.069	3.45	84.525	0.002	0.1	32
Residual Fuel Oil	2400000	47.4	56880	56311.2	206474.4	206474.4	0.0035	4.2	102.9	N/A	0	0
Anthracite Coal	100000	62.1	3105	3073.95	11271.15	11271.15	0.0221	1.105	27.0725	N/A	0	0
Natural Gas	6200000	31.9	98890	98395.55	360783.6833	360783.6833	0.0025	7.75	189.875	N/A	0	0
subtotals	**16400000**				**1182924.233**	**1182924.233**		**21.985**	**538.6325**		**0.1**	**32**
INDUSTRIAL												
Distillate Fuel Oil	2500000	44	55000	54450	199650	199650	0.0013	1.625	39.8125	N/A	0	0
Kerosene	100000	43.5	2175	2153.25	7895.25	7895.25	0.013	0.65	15.925	N/A	0	0
LPG	1500000	37.8	28350	28066.5	102910.5	102910.5	N/A	0	0	N/A	0	0
Lubricants *	100000	44.6	2230	N/A	-1115	-1115	N/A	0	0	N/A	0	0
Asphalt and Road Oil*	2100000	45.5	47775	N/A	-47775	-47775	N/A	0	0	N/A	0	0
Misc. Pet. Prod.	1000000	44.7	22350	22126.5	81130.5	81130.5	N/A	0	0	N/A	0	0
Motor Gasoline	500000	42.8	10700	10593	38841	38841	0.069	17.25	422.625	0.002	0.5	160
Residual Fuel Oil	9000000	47.4	213300	211167	774279	774279	0.0064	28.8	705.6	N/A	0	0
Bituminous Coal	2000000	56	56000	55440	203280	203280	0.0053	5.3	129.85	N/A	0	0
Natural Gas	3800000	31.9	60610	60306.95	221125.4833	221125.4833	0.0029	5.51	134.995	N/A	0	0
subtotals	**22600000**				**1580221.733**	**1580221.733**		**59.135**	**1448.8075**		**0.5**	**160**
TRANSPORTATION												
Aviation Gasoline€	200000	41.6	4160	4118.4	15100.8	15100.8	0.133	13.3	325.85	0.002	0.2	64
Diesel€	7700000	44	169400	167706	614922	614922	0.022	84.7	2075.15	0.004	15.4	4928
LPG€	1000000	37.8	18900	18711	68607	68607	0.066	33	808.5	N/A	0	0
Jet Fuel€	2200000	43.5	47850	47371.5	173695.5	173695.5	0.0044	4.84	118.58	N/A	0	0
Lubricants *€	300000	44.6	6690	6623.1	12142.35	12142.35	N/A	0	0	N/A	0	0
Motor Gasoline**€	65100000	42.8	1393140	1379209	5057098.2	5057098.2	0.023852	776.3826	19021.3737	0.017889	582.28695	186331.824
Natural Gas€	300000	31.9	4785	4761.075	17457.275	17457.275	0.61	91.5	2241.75	N/A	0	0
subtotals	**76800000**				**5959023.125**	**5959023.125**		**1003.7226**	**24591.2037**		**597.88695**	**191323.824**
ELECTRIC UTILITIES												
Distillate Fuel Oil	300000	44	6600	6534	23958	23958	0.00007	0.0105	0.25725	N/A	0	0
Residual Fuel Oil	14400000	47.4	341280	337867.2	1238846.4	1238846.4	0.0015	10.8	264.6	N/A	0	0
Bituminous Coal	35420753	56	991781.1	981863.3	3600165.335	3600165.335	0.0013	23.02348945	564.0754915	N/A	0	0
Natural Gas	138	31.9	2.2011	2.190095	8.0303465	8.0303465	0.0002	0.0000138	0.0003381	N/A	0	0
subtotals	**50120891**				**4862977.765**	**4862977.765**		**33.83400325**	**828.9330796**		**0**	**0**
					(CO2 tons)	(CO2 TCDE)		(CH4 tons)	(CH4 TCDE)		(N2O tons)	(N2O TCDE)
Total Consumption (MMBtu)	**201720891**			Totals	**16251615.79**	**16251615.79**	Totals	**1264.646603**	**30983.84178**	Totals	**598.48695**	**191515.824**

* Lubricant and asphalt and road oil numbers reflect the substance is used and stored as nonfuel in the industrial process, not combusted. In these individual cases the CO2 emission value has been multiplied by a percent carbon sequestered value. See Table A-I.1c

** CH4 and N2O emission factors are weighted for distribution of fleet, see Table A-I.1b.

Table A-I.1a Energy Use Sector
Fossil Fuel Consumption Category

Column A: Fuel Consumption (million Btu)

Sources: U.S. Department of Energy, State Energy Data Report 1993 Consumption Estimates, DOE/EIA-214(93), pages 204-207.

New Hampshire Department of Environmental Services, Air Resources Division (NHDES-ARD), 1993 SO2-NOx Emission Calculations database.

Notes: All of the fuel consumption estimates were extracted from the New Hampshire section of the State Energy Data Report 1993 Consumption Estimates except for bituminous coal and natural gas under the electric utilities subcategory. These figures were derived from surveys conducted on fuels sold within the state although not necessarily consumed in the state. The numbers for bituminous coal and natural gas are actual consumption figures reported by the state's only utility (Public Service of New Hampshire) to NHDES-ARD.

Column B: Carbon Content Coefficient (lbs C/MMBtu).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 1-3.

Notes: Carbon content coefficients represent the amount of carbon emitted per unit of useful energy obtained by burning a specific type of fuel.

Column C: Total Carbon in Fuel Consumed (tons C).

Source: [Column A (MMBtu)] x [Column B (lbs/MMBtu)] ÷ [2000 lbs/ton] = Column C

Column D: Total Carbon Oxidized (tons C).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, page 1-13.

Notes: For solid and liquid fuels, 99% of total carbon (Column C) is assumed to be oxidized.
For gaseous fuels, 99.5% of total carbon (Column C) is assumed to be oxidized.

Column E: Carbon Dioxide Emissions (tons CO2).

Source: [Column D (tons C oxidized)] x [molecular weight ratio of CO2 to C (44/12)] = Column E

Column F: Carbon Dioxide Emissions (TCDE).

Source: [Column E (tons CO2)] x [GWP of CO2 (1.0)] = Column F

Column G: Methane Emission Factor (lbs CH4/MMBtu).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, Tables D14-2 through D14-6.

Notes: These factors are extracted from the Radian Corporation Report prepared for the EPA.

Column H: Methane Emissions (tons CH4).

Source: [Column A (MMBtu)] x [Column G (lbs CH4/MMBtu)] ÷ [2000 lbs/ton] = Column H

Column I: Methane Emissions (TCDE).

Source: [Column H (tons CH4)] x [GWP of CH4 (24.5)] = Column I

Column J: Nitrous Oxide Emission Factor (lbs N20/MMBtu).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, tables in Sections D-1 and D-13. See also Table A-I.1b.

Notes: Emission factors for motor gasoline in the Transportation subcategory represent a weighted emission factor based on estimated fleet vehicle type distribution. See Table A-I.1b.

Column K: Nitrous Oxide Emissions (tons N2O).

Source: [Column A (MMBtu)] x [Column J (lbs N2O/MMBtu)] ÷ [2000 lbs/ton] = Column K

Column L: Nitrous Oxide Emissions (TCDE).

Source: [Column K (tons N2O)] x [GWP of N2O (320.0)] = Column L

TABLE A- I. 1b Energy Use Sector: Transportation Subcategory Weighted Emission Factors For Motor Gasoline

	A	B	C	D	E	F
			CH4 Emission Factor (lbs/MMBtu)		N2O Emission Factor (lbs/MMBtu)	
VEHICLE TYPE						
PASSENGER CARS	70.00%					
Advanced 3-way catalyst		66%	0.016	0.007392	0.015	0.00693
Early 3-way catalyst		30%	0.025	0.00525	0.029	0.00609
Non-catalyst		4%	0.069	0.001932	0.002	0.000056
		100%	**subtotal**	**0.014574**	**subtotal**	**0.013076**
LIGHT-DUTY TRUCKS	25.50%					
Advanced 3-way catalyst		66%	0.025	0.004208	0.015	0.0025245
Early 3-way catalyst		30%	0.032	0.002448	0.029	0.0022185
Non-catalyst		4%	0.059	0.000602	0.002	0.0000204
		100%	**subtotal**	**0.007257**	subtotal	**0.0047634**
HEAVY-DUTY TRUCKS	4.00%					
3-way catalyst		66%	0.022	0.000581	0.001	0.0000264
Non-catalyst		30%	0.022	0.000264	0.001	0.000012
Uncontrolled		4%	0.044	7.04E-05	0.001	0.0000016
		100%	**subtotal**	**0.000915**	**subtotal**	**0.00004**
MOTORCYCLES	0.50%					
Non-catalytic		50%	0.155	0.000388	0.002	0.000005
Uncontrolled		50%	0.287	0.000718	0.002	0.000005
		100%	**subtotal**	**0.001105**	**subtotal**	**0.00001**
Transportation Subcategory Motor Gasoline			Weighted CH4 Emission Factor (lbs/MMBtu)	**0.023852**	Weighted N2O Emission Factor (lbs/MMBtu)	**0.0178894**

Table A.1b **Energy Use Sector**
Fossil Fuel Consumption Category
Trasnportation Subcategory
Weighted Emission Factors For Motor Gasoline

Column A: Percentage of fleet represented by vehicle type (e.g., passenger cars represent 70% of fleet in New Hampshire).

Sources: Estimated from U.S.E.P.A. Mobile 5a (computer model for estimating mobile source emissions) default values for fleet distribution.

Column B: Percentage of catalyst technology within vehicle type (e.g., 66% of passenger cars have advanced 3-way catalysts, passenger cars represent 70% of overall fleet)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Section D-13.

Column C: Methane Emission Factor (lbs/MMBtu)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Section D-13.

Column D: Contribution to weighted CH4 emission factor for motor gasoline in transportation subcategory.

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, Section D-13.

[Column A (%)]x[Colunm B (%)]x[Colunm C (lbs/MMBtu)]= Column D

Column E: Nitrous Oxide Emission Factor (lbs/MMBtu)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Section D-13.

Column F: Contribution to weighted N2O emission factor for motor gasoline in transportation subcategory.

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, Section D-13.

[Column A (%)]x[Colunm B (%)]x[Colunm E (lbs/MMBtu)]= Column F

Table A-I.1c Energy Use Sector

Carbon Stored by Non-Fuel Use

	A	B	C	D	E	F
	Product Consumption **(MMBtu)**	% Used as Non-Fuel **(%)**	Non-Fuel Consumption **(MMBtu)**	Carbon Content Coefficient **(lbs C/MMBtu)**	Percent Carbon Sequestered by Non-Fuel **(%)**	Stored Non-Fuel Carbon **(tons C)**
INDUSTRIAL						
Asphalt and Road Oil	2100000	1	2100000	45.5	1	47775
Lubricants	100000	1	100000	44.6	0.5	1115

Total (tons C) **48890**

Table A-I.1c Energy Use Sector
Carbon Stored by Non-Fuel Use

Column A: Fuel Consumption (million Btu)

Sources: U.S. Department of Energy, State Energy Data Report 1993 Consumption Estimates, DOE/EIA-214(93), pages 204-207.

New Hampshire Department of Environmental Services, Air Resources Division (NHDES-ARD), 1993 SO2-NOx Emission Calculations database.

Notes: All of the fuel consumption estimates were extracted from the New Hampshire section of the State Energy Data Report 1993 Consumption Estimates except for bituminous coal and natural gas under the electric utilities subcategory. These figures were derived from surveys conducted on fuels sold within the state although not necessarily consumed in the state. The numbers for bituminous coal and natural gas are actual consumption figures reported by the state's only utility (Public Service of New Hampshire) to NHDES-ARD.

Column B: Percent Used as Non-Fuel

Notes: The percentage of product that has non-fuel uses versus the proportion burned as fuel.

Column C: Non-Fuel Consumption (MMBtu)

Source: [Column A (MMBtu)] x [Column B (%)] = Column C (MMBtu)

Column D: Carbon Content Coefficient (lbs C/MMBtu)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 1-3.

Notes: Carbon content coefficients represent the amount of carbon emitted per unit of useful energy obtained by burning a specific type of fuel.

Column E: Percent Carbon Sequestered by Non-Fuel (%):

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table D1-3.

Column F: Stored Non-Fuel Carbon (tons C):

Source: [Column C (MMBtu)] x [Column D (lbs C/MMBtu)] x [Column E (%)]/2000 = Column F (tons C)

Table A-I.2 Energy Use Sector - Biofuel Consumption Category

SUBCATEGORY	A Consumption (dry tons)	B Carbon Fraction (tons C/dry ton)	C Total Carbon (tons C)	D Total Carbon Oxidized (tons C)	E CO2* Emissions (tons CO2)	F CO2* Emissions GWP = 1.0 (TCDE)	G Energy Content (MMBtu/ton)	H CH4 Emission Factor (lbs/MMBtu)	I CH4 Emissions (tons CH4)	J CH4 Emissions GWP = 24.5 (TCDE)
Residential										
Wood	312000	0.475	148200	133380	489060	489060	10.4	0.164	266.0736	6518.8032
Industrial										
Wood	311600	0.475	148010	133209	488433	488433	10.4	0.0331	53.632592	1313.998504
Utilities										
Wood	770756	0.475	366109.1	329498.2	1208160.03	1208160.03	10.4	0.0398	159.5156618	3908.133713
MSW	311564	0.22	68544.08	61689.67	226195.464	226195.464	9.7	0.0015	2.2666281	55.53238845
Governmental										
MSW	68346	0.22	15036.12	13532.51	49619.196	49619.196	9.7	0.0015	0.49721715	12.18182018

subtotal (wood)	**1394356**			(CO2 tons)*	(CO2 TCDE)*		(CH4 tons)	(CH4 TCDE)
subtotal (MSW)	**379910**		**Totals**	**2461467.69**	**2461467.69**	**Totals**	**481.985699**	**11808.64963**

* Carbon Dioxide emissions for biomass fuels are only tabulated and are not included in this GHG inventory.

Table A-I.2 Energy Use Sector
Biofuel Consumption Category

Column A: Fuel Consumption (dry tons)

Sources: New Hampshire Governor's Office of Energy and Community Services, 1993-94 Heating Season Cordage per memo from George Hunton, June 1995.

NHDES-ARD, List of Wood-Fired Boilers database, March 1994.

NHDES-ARD,Municipal Solid Waste Incinerator database, January 1995.

Notes: The residential component of wood consumption was derived from a survey. Industrial and utility wood consumption totals were reported by all permitted facilities. Municipal solid waste totals are derived from their permitted totals per day.

Column B: Carbon Fraction of Dry Matter (ton C/ton dry matter).

Source: Wood - U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 1-11.

Municipal solid waste - The Maine greenhouse gas emissions inventory and action plan, pages A8-A9.

Column C: Total Carbon in Fuel Consumed (tons C).

Source: [Column A (dry tons] x [Column B (tons C/ton dry matter)] = Column C

Column D: Total Carbon Oxidized (tons C).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, page 1-13.

Notes: For wood and municipal solid waste, 90% of total carbon (Column C) is assumed to be oxidized.

Column E: Carbon Dioxide Emissions (tons CO2).

Source: [Column D (tons C oxidized)] x [molecular weight ratio of CO2 to C (44/12)] = Column E

Column F: Carbon Dioxide Emissions (TCDE).

Source: [Column E (tons CO2)] x [GWP of CO2 (1.0)] = Column F

Column G: Energy Content (MMBtu/ton).

Source: AP-42, Fifth Edition, Volume I, Appendix A, Miscellaneous Data and Conversion Factors.

Municipal solid waste - The Maine greenhouse gas emissions inventory and action plan, pages A8-A9.

Column H: Methane Emission Factor (lbs CH4/MMBtu).

Source: Wood - U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Tables D14-2, D14-3, D14-5.

Municipal solid waste - The Maine greenhouse gas emissions inventory and action plan, pages A8-A9.

Column I: Methane Emissions (tons CH4).

Source: [Column A (dry tons)]x [Column G (MMBtu/dry ton)] x [Column H (lbs CH4/MMBtu)] ÷ [2000lbs/ton] = Column I

Column J: Methane Emissions (TCDE).

Source: [Column H (tons CH4)] x [GWP of CH4 (24.5)] = Column J

Table A-I.3

Energy Use Sector
Natural Gas Pipeline Leaks Category
Methane Emissions

	A	B	C	D
	Fuel Consumption **(MMBtu)**	CH4 Emission Factor **(lbs/MMBtu)**	CH4 Emissions **(tons CH4)**	CH4 Emissions GWP = 24.5 **(TCDE)**
LEAKAGE				
PROCESSING, TRANSPORT, DISTRIBUTION	16500138	0.204	**1683.0141**	**41233.84486**

Table A-I.3 Energy Use Sector
Natural Gas Pipeline Leaks Category

Column A: Fuel Consumption (MMBtu)

Source: U.S. Department of Energy, State Energy Data Report 1993 Consumption Estimates, DOE/EIA-214(93) pages 204-207.

Column B: Methane Emission Factor (lbs CH_4/MMBtu).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, Tables 3-2.

Column C: Methane Emissions (tons CH_4).

Source: [Column A (MMBtu)] x [Column B (lbs CH_4/MMBtu)] ÷ [2000 lbs/ton] = Column C

Column D: Methane Emissions (TCDE).

Source: [Column C (tons CH_4)] x [GWP of CH_4 (24.5)] = Column D

Table A-II.1 Industrial Processes Sector
Carbonate Use

	A	B	C		D	E
CARBONATE	**Total Consumed (tons)**	**Emission Factor (ton C/ton carbonate)**	**Total Carbon (tons C)**		**CO2 Emissions (44/12) (tons CO2)**	**CO2 Emissions GWP = 1.0 (TCDE)**
LIMESTONE (CaCO3)						
paper mills	152750	0.12	18330		67210	67210
SODA ASH (NaCO3)						
paper mills	1732	0.415	718.78		2635.526667	2635.527
textiles, glass, misc.	0.35	0.415	0.14525		0.532583333	0.532583
water treament	60.86	0.415	25.2569		92.60863333	92.60863
					69938.66788	**69938.67**

Table A-II.1 Industrial Processes Sector
Carbonate Use

Column A: Total Consumption (tons)

Source: Phone reports of carbonate from officials at industrial facilities in New Hampshire that use carbonates.

Column B: Carbon Emission Factor (tons C/ton carbonate).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions Second Edition, 1995, Sections D2.5, D2.6.

Column C: Total Carbon (tons C).

Source: [Column A (tons carbonate)] x [Column B (tons C/ton carbonate)] = Column C

Column D: Carbon Dioxide Emissions (tons CO2).

Source: [Column D (tons C oxidized)] x [molecular weight ratio of CO2 to C (44/12)] = Column D

Column E: Carbon Dioxide Emissions (TCDE).

Source: [Column E (tons CO2)] x [GWP of CO2 (1.0)] = Column E

Table A-III.1

Waste Management Sector
Landfills Category
Methane Emissions

LANDFILL CLASS	A Fraction Of Total Waste	B State Total Waste In Place* (tons)	C CH4 Emission Factor	D Number Of Landfills	E CH4 Generated** (cu ft/day)	F Conversion Factor*** (ton CH4/year) (cu ft CH4/day)	G CH4 Emissions (tons)	H CH4 Recovered (tons)	I CH4 Net Emissions (tons)	J CH4 Emissions GWP = 24.5 (TCDE)
Small Landfills****	0.11	1797102.5	0.35	n/a	69188.444	0.0077	532.75102	n/a	532.751	13052.40002
Large Landfills****	0.89	14540193	n/a	8	7132450.1	0.0077	54919.865	12600	42319.87	1036836.704
									(CH4 tons)	(CH4 TCDE)
TOTALS	1	16337295			7201638.5		55452.617	12600	42852.62	1049889.104

* Waste In Place (State) = (30 years)(Current State Population)(Per Capita Waste Generation)(Percent Landfilled)(Population Growth Correction Factor - 2%)

= (30 years)(1,125,000)(1 ton/year/capita)(0.642)(.754)

= 16,337,295 tons (see note for column A)

** small landfill formula: [0.35 * weight of waste in place at small landfills]
large landfill formula: [(number of large landfills) * (419,000 + (0.26*average weight per large landfill))]

rection Factor - 2%)

Table A-III.1 Waste Management Sector
Landfills Category

Column A: Fraction of Total Waste

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 5-2.

Column B: State Total Waste In Place (tons).

Source: See note (*) on Table A-III.1 for computation of state total waste in place.

Notes: Population information from 1990 census data provided by the New Hampshire Governor's Office of State Planning, per capita waste generation provided by NHDES Waste Management Division, percent landfilled from NHDES Waste Management Division, population growth correction factor from U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 5-1.

Column C: Methane Emission Factor

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 5-5,6.

Column D: Number of Landfills

Source: NHDES Waste Management Division.

Column E: CH4 Generated (cu ft/day).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 5-5,6.

Column F: Conversion Factor (tons CH4/year ÷ cu ft CH4/day).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 5-5.

Column G: Methane Emissions (tons CH4).

Source: [Column E (cu ft CH4/day)]x [Column F (tons CH4/year ÷ cu ft CH4/day)] = Column G

Column H: Methane Recovered (tons CH4).

Source: NHDES Air Resources - reported during permitting process, 1994.

Column I: Methane Net Emissions (tons CH_4).

Source: [Column G (tons CH_4)] - [Column H (tons CH_4)] = Column I

Column J: Methane Emissions (TCDE).

Source: [Column I (tons CH_4)] x [GWP of CH_4 (24.5)] = Column J

Table A-III.2 **Waste Management Sector**
Wastewater Treatment Category
Methane Emissions

	A	B	C	D	E	F	G	H	I	J
SOURCE	Population (capita)	Wastewater BOD (lbs/capita/day)	BOD Generated (lbs BOD/day)	Fraction naerobicall Treated	Total Treated (lbs BOD/year)	CH4 Emission Factor (lbs CH4/lb BOD)	CH4 Emissions (tons)	CH4 Recovered (tons)	CH4 Net Emissions (tons)	CH4 Emissions GWP = 24.5 (TCDE)
Wastewater Treatment	1125000	0.1356	152550	0.089	4955586.75	0.22	545.1145	250	**295.1145**	**7230.306**

Table A-III.2 Waste Management Sector
Wastewater Treatment Category

Column A: Population (capita).

Source: Population information from 1990 census data provided by the New Hampshire Governor's Office of State Planning.

Notes: The 1993 population was based on an intercensal estimate by the New Hampshire Governor's Office of State Planning from the 1990 census.

Column B: Wastewater Biological Oxygen Demand (lbs BOD/capita/day).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 12-2.

Notes: National average BOD generated per capita per day.

Column C: BOD Generated (lbs BOD/day)

Source: [Column A (capita)]x [Column B (lbs/capita/day)] x [365 days/year] = Column C

Column D: Fraction Anaerobically Treated

Source: NHDES Water Division, Wastewater Treatment Plants - 1993 Flow Data.

Column E: Total BOD Treated (lbs BOD/year)

Source: [Column C (lbs BOD/year)]x [Column D] = Column E

Column F: CH4 Emission Factor (lbs CH4/lb BOD).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 12-2.

Column G: Methane Emissions (tons CH4).

Source: [Column E (lbs BOD/year)] x [Column F (lbs CH4/lb BOD)] ÷ [2,000 lbs/ton] = Column G

Column H: Methane Recovered (tons CH4).

Source: Reports from three municipalities and one industry known to have anaerobic digesters.

Column I: Methane Net Emissions (tons CH_4).

Source: [Column G (tons CH_4)] - [Column H (tons CH_4)] = Column I

Column J: Methane Emissions (TCDE).

Source: [Column I (tons CH_4)] x [GWP of CH_4 (24.5)] = Column J

Table A-IV.1

Agriculture Sector
Enteric Fermentation Category
Methane Emissions

SUBCATEGORY	A Number Of Animals (head count)	B CH4 Emission Factor (lbs CH4/head/year)	C CH4 Emissions (tons CH4)	D CH4 Emissions GWP = 24.5 (TCDE)
Dairy Cattle				
Heifers	11000	85.7	471.35	11548.075
Mature Cows	20000	258.5	2585	63332.5
Beef Cattle				
Heifers	1000	91.3	45.65	1118.425
Mature Cows	4000	135.3	270.6	6629.7
Bulls	1000	220	110	2695
Other Domesticated Animals				
Sheep	7100	17.6	62.48	1530.76
Goats	5000	11	27.5	673.75
Pigs	8500	3.3	14.025	343.6125
Horses, et al	12000	39.6	237.6	5821.2
			(CH4 tons)	(CH4 TCDE)
		Totals	**3824.205**	**93693.0225**

Table A-IV.1 Agriculture Sector
Enteric Fermentation Category

Column A: Number of Animals (head count).

Source: U.S. Department of Agriculture, New England Agricultural Statistics, 1993 Annual Production, Concord, NH.

Column B: Methane Emission Factor (lbs CH4/head/year).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 6-1.

Notes: Emission factor for heifers is average of factors Table 6-1 provides for cattle age: 0-12 months and 12-24 months.

Column C: Methane Emissions (tons CH4).

Source: [Column A (head)] x [Column B (lbs CH4/head/year)] ÷ (2,000 lbs/ton) = Column C

Column D: Methane Emissions (TCDE).

Source: [Column C (tons CH4)] x [GWP of CH4 (24.5)] = Column D

Table A-IV.2

Agriculture Sector
Manure Management Category
Methane Emissions

SUBCATEGORY	A Number Of Animals (head count)	B Animal Mass (lbs/head)	C Volatile Solids (VS) Per Mass (lbs VS/lbs/year)	D Total Volatile Solids (VS) (lbs VS)	E Maximum CH4 Production Emission Factor (cu ft/lbs VS)	F Potential CH4 Emission (cu ft)	G Manure Management Type	H Management Usage **(percentage)**	I CH4 Emission Factor (% of potential **CH4 emission)**	J CH4 Emissions* **(tons CH4)**	K CH4 Emissions GWP = 24.5 **(TCDE)**
Dairy Cattle											
Heifers	11000	903	3.65	36255450	3.84	139220928	daily spread	0.2	0.002	1.14996487	28.1741392
							solid storage	0.4	0.008	9.19971892	225.3931136
							liquid/slurry	0.4	0.163	187.444273	4592.384689
Mature Cows	20000	1345	3.65	98185000	3.84	377030400	daily spread	0.2	0.002	3.1142711	76.29964205
							solid storage	0.4	0.008	24.9141688	610.3971364
Beef Cattle											
Heifers	1000	794	2.6	2064400	2.72	5615168	pasture	1	0.008	0.92762575	22.72683096
Mature Cows	4000	1102	2.6	11460800	2.72	31173376	pasture	1	0.008	5.14984172	126.171122
Bulls	1000	1587	2.6	4126200	2.72	11223264	pasture	1	0.008	1.85408321	45.42503871
Other Domesticated Animals											
Sheep	7100	154	3.36	3673824	3.04	11168424.96	pasture	1	0.008	1.8450238	45.20308318
Goats	5000	141	3.48	2453400	2.72	6673248	pasture	1	0.008	1.10242057	27.00930396
Poultry-layers	168000	3.5	4.4	2587200	5.45	14100240	deep pit stacks	1	0.1	29.1169956	713.3663922
Poultry-broilers	13000	1.5	6.2	120900	4.81	581529	litter	1	0.1	1.20085739	29.42100593
Turkeys	20000	7.5	3.32	498000	4.81	2395380	litter	1	0.1	4.9464597	121.1882627
Swine-market	6000	101	3.1	1878600	7.53	14145858	drylot	0.9	0.008	2.10320617	51.5285511
							anaerobic lagoon	0.05	0.9	13.1450385	322.0534444
							pit storage<1 month	0.05	0.082	1.19765907	29.34264716
Swine-breeding	2500	399	3.1	3092250	5.77	17842282.5	drylot	0.9	0.008	2.65279056	64.99336877
							anaerobic lagoon	0.05	0.9	16.579941	406.2085548
							pit storage>1 month	0.05	0.163	3.00281154	73.56888271
Horses, et al	12000	992	3.65	43449600	5.29	229848384	pasture	0.1	0.008	3.7970953	93.02883494
							paddock	0.9	0.008	34.1738577	837.2595145
										(CH4 tons)	(CH4 TCDE)
									Totals	**856.244294**	**20977.98521**

* The conversion factor for methane is 0.0413 lbs/cu ft, and 2000 lbs/ton.

Table A-IV.2 Agriculture Sector
Manure Management Category

Column A: Number of Animals (head count).

Sources: U.S. Department of Agriculture, New England Agricultural Statistics, 1993 Annual Production, Concord, NH.

Horse population (includes mules, asses, donkeys and draft horses) from Office of State Veterinarian (Dr. Clifford McGuiness).

Column B: Animal Mass (lbs/head).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 7-10.

Column C: Volatile Solids Per Mass (lbs VS/lbs/year)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 7-10.

Column D: Total Volatile Solids (lbs VS).

Source: [Column A (head)] x [Column B (lbs/head)] x [Column C (lbs VS/lbs/year)] = Column D

Column E: Maximum CH4 Production Emission Factor (cu ft CH4/lbs VS).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 7-11.

Column F: Potential Emissions (cu ft CH4).

Source: [Column D (lbs VS)]x [Column E (cu ft CH4/lbs VS)] = Column F

Column G: Manure Management Type.

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page D7-6.

Column H: Management Usage (percentage).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Tables 7-2 through 7-9.

Column I: CH4 Emission Factor (% of potential CH4 emissions).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 7-12.

Column J: Methane Emissions (tons CH4).

Source: [Column F (cu ft)] x [Column H (%)] x [Column I (%)] x [0.0413 lbs/cu ft] ÷ [2,000 lbs/ton] = Column J

Column K: Methane Emissions (TCDE).

Source: [Column J (tons CH4)] x [GWP of CH4 (24.5)] = Column K

Table A-IV.3

Agriculture Sector
Soil Management Category
Liming Agents - Carbon Dioxide Emissions

FERTILIZER	A Fertilizer Consumption 1992 **(tons)**	B Fertilizer Consumption 1993 **(tons)**	C Fertilizer Consumption 1994 **(tons)**	D Average Fertilizer Consumption **(tons)**	E Nitrogen Content of Fertilizer **(percentage)**	F Average Nitrogen Consumption **(tons)**	G Emission Factor (% N2O - N produced)	H N2O-N Emissions (tons N2O-N)	I N2O Emissions (44/28) (tons N2O)	J N2O Emissions GWP = 320.0 (TCDE)
Ammonium Sulfate	8	11	17	12	0.21	2.52	0.0117	0.029484	0.046332	14.82624
Ammonium Nitrate	70	75	34	59.66666667	0.335	19.98833333	0.0117	0.2338635	0.36749979	117.5999314
Urea	501	1346	1489	1112	0.46	511.52	0.0117	5.984784	9.40466057	3009.491383
Ammonium Phosphate	250	592	353	398.3333333	0.27	107.55	0.0117	1.258335	1.97738357	632.7627429
Anhydrous Ammonia	0	0	0	0	0.82	0	0.0117	0	0	0
Aqua Ammonia	0	0	0	0	0.205	0	0.0117	0	0	0
Ammonium Thiosulfate	0	0	1	0.333333333	0.185	0.061666667	0.0117	0.0007215	0.00113379	0.362811429
Nitrogen Solutions	135	153	22	103.3333333	0.35	36.16666667	0.0117	0.42315	0.66495	212.784
Other (nitgrogen fertilizers)	1393	1790	957	1380	0.3	414	0.0117	4.8438	7.61168571	2435.739429
									(N2O tons)	(N2O TCDE)
								Totals	**20.0736454**	**6423.566537**

LIMING AGENT	K Liming Agent Consumption **(tons)**	L Emission Factor **(tons C/ ton agent)**	M Carbon Emissions **(tons C)**	N CO2 Emissions (44/12) **(tons CO2)**	O CO2 Emissions GWP = 1.0 **(TCDE)**
Limestone	12031	0.12	1443.72	2268.70286	2268.702857
				(CO2 tons)	(CO2 TCDE)
			Totals	**2268.70286**	**2268.702857**

Table A-IV.3 Agriculture Sector
Soil Management Category

Column A: Fertilizer Consumption, 1992 (tons)

Sources: Tennessee Valley Authority, Commercial Fertilizers, December, ‘92, ‘93, ‘94, pages 10-11, 10-14, 10- 15, 10-28.

Notes: A three year average was utilized in the computation of emissions from fertilizer use.

Column B: Fertilizer Consumption, 1993 (tons)

Sources: Tennessee Valley Authority, Commercial Fertilizers, December, ‘92, ‘93, ‘94, pages 10-11, 10-14, 10- 15, 10-28.

Notes: A three year average was utilized in the computation of emissions from fertilizer use.

Column C: Fertilizer Consumption, 1994 (tons)

Sources: Tennessee Valley Authority, Commercial Fertilizers, December, ‘92, ‘93, ‘94, pages 10-11, 10-14, 10- 15, 10-28.

Notes: A three year average was utilized in the computation of emissions from fertilizer use.

Column D: Average Fertilizer Consumption (tons)

Source: [Column A (tons)] + [Column B (tons)] + [Column C (tons)] ÷ 3 = Column D

Column E: Nitrogen Content of Fertilizer (percentage).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 9-1.

Column F: Average Nitrogen Consumption (tons).

Source: [Column D (tons)] x [Column E (% nitrogen)] = Column F

Column G: N2O Emission Factor (%N20-N).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 9-2.

Column H: N2O-N Emissions (tons N2O-N).

Source: [Column F (tons)]x [Column G (tons N2O-N)] = Column H

Column I: Nitrous Oxide Emissions (tons N2O).

Source: [Column H (tons N2O)] x [molecular weight ratio of N2O to N (44/28)] = Column I

Column J: Nitrous Oxide Emissions (TCDE).

Source: [Column I (tons N2O)] x [GWP of N2O (320.0)] = Column J

Column K: Liming Agent Consumption (tons).

Source: New Hampshire Department of Agriculture, Bureau of Markets, 1993 Agricultural Liming Materials Report, February 16, 1994.

Column L: Carbon Emission Factor (tons C/ton agent).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page D2-5.

Column M: Carbon Emissions (tons C).

Source: [Column K (tons agent)] x [Column L (tons C/ton agent)] = Column M

Column N: CO2 Emissions (tons CO2).

Source: [Column M (tons CO2)] x [molecular weight ratio of CO2 to C (44/28)] = Column N

Column O: CO2 Emissions (TCDE).

Source: [Column N (tons CO2)] x [GWP of CO2 (1.0)] = Column O

Table A-IV.4

Agriculture Sector
Crop Waste Burning
Methane, Nitrous Oxide Emissions

CROP	A Area Burned 1993 **(acres)**	B Dry Matter (DM) Burned **(lbs/acre)**	C Carbon Content **(lbs C/lb DM)**	D Total Carbon Burned **(lbs C)**	E Fraction of Carbon Oxidized **(%)**	F Total Carbon Oxidized **(lbs CO2-C)**	G CH4 Emissions Ratio (lbs CH4/lbs CO2-C)	H CH4 Emissions (tons CH4-C)	I CH4 Emissions (16/12) (tons CH4) **(tons CH4)**	J CH4 Emissions GWP = 24.5 (TCDE) **(CH4 TCDE)**
Low Bush Blueberries	650	785	0.45	229612.5	0.88	202059	0.003	0.3030885	**0.4**	**10**

K Nitrogen/Carbon Emissions Ratio **(lbs N/lb C)**	L Total Nitrogen Released **(lbs N)**	M N2O Emissions Ratio **(tons N2O-N)**	N N2O Emissions (44/28) **(tons N2O)**	O N2O Emissions GWP = 320.0 **(TCDE)**
			(tons N2O)	**(N2O TCDE)**
0.0511	11733.19875	0.007	**0.06**	**21**

Table A-IV.4 Agriculture Sector
Crop Waste Burning Category

Column A: Area Burned (acres).

Source: UNH College of Life Sciences, Durham, NH, conversation with Bill Lord.

Notes: Lowbush blueberry area is limited by soils and locale and is generally regarded as a natural planting.

Column B: Dry Matter Burned (lbs dry matter/year).

Source: D.W. Smith and R.J. Hilton, The Comparative Effects of Pruning By Burning or Clipping on Lowbush Blueberries in Northeastern Ontario, Journal of Applied Ecology, Volume 8, pages 781-789.

Notes: Dr. Jeffrey Simmons, University of Maine, assisted with numbers process and citations.

Column C: Carbon Content (lbs C/lb dry matter).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table D11-1.

Column D: Total Carbon Burned (lbs C).

Source: [Column A (acres)] x [Column B (lbs DM/acre)]x [Column C (lbs C/lb DM) = Column D

Column E: Fraction pf Carbon Oxidized (%).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 11-3.

Column F: Total Carbon Oxidized (lbs CO2-C)

Source: [Column D (lbs C)] x [Column E (% carbon oxidized)] = Column F

Column G: CH4 Emissions Ratio (lbs CH4/lb CO2-C)

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table D11-2.

Column H: CH4 Emissions (tons CH4-C).

Source: [Column F (lbs CO2-C)]x [Column G (lbs CH4/lb CO2-C)] ÷ [2,000 lbs/ton] = Column H

Column I: CH4 Emissions (tons CH4).

Source: [Column H (tons CH4-C)] x [molecular weight ratio of CH4 to C (16/12)] = Column I

Column J: CH4 Emissions (TCDE).

Source: [Column I (tons CH4)] x [GWP of CH4 (24.0)] = Column J

Column K: Nitrogen/Carbon Emissions Ratio (lbs N/lb C).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table D11-1.

Column L: Total Nitrogen Released (lbs N).

Source: [Column D (lbs C)] x [Column K (lbs N/lb C)] = Column L

Column M: N2O Emissions Ratio (tons N2O-N).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table D11-2.

Column N: Nitrous Oxide Emissions (tons N2O).

Source: [Column L (lbs N)] x [Column M (tons N2O-N)] ÷ [2,000 lbs/ton] x [molecular weight ratio of N2O to N (44/28)] = Column N

Column O: Nitrous Oxide Emissions (TCDE).

Source: [Column N (tons N2O)] x [GWP of N2O (320.0)] = Column O

Table A-V.1 **Land Use Sector** **c**

Changes In Forest and Woody Biomass Stock

	A	B	C	D	E
	Area of Biomass/Forest Stocks **(acres)**	Annual Growth Rate **(tons dm/acre/yr)**	Annual Biomass Increment **(tons dm/yr)**	Carbon Fraction of Dry Matter **(tons C/ton dm)**	Total Carbon Uptake Increment **(tons C/yr)**
FORESTED LAND					
Hardwood	2508212	0.89	2232308.68	0.498	1111689.723
Softwood	2171288	1.3	2822674.4	0.521	1470613.362
	A-1			**D-1**	**E-1**

	Number Of Trees **(trees)**	Carbon Fraction Of Trees **(tons C/tree/yr)**	Total Carbon Uptake Increment **(tons C/yr)**
DEVELOPED LAND			
Mixed hardwood/softwood	69360000	0.003051181	211629.9213

(tons C/yr)

TOTAL CARBON UPTAKE = **2793933.006**

	F	G	H	I	J	K	L	M	N	O
	Commercial Timber Harvested **(cu ft/yr)**	Biomass Conversion/ Expansion Ratio **(tons dm/cu ft)**	Total Biomass Removed In Comm. Harvest **(tons dm/yr)**	Fuelwood Consumed **(tons dm/yr)**	Total Other Wood Used **(tons dm/yr)**	Gross Biomass Consumed **(tons dm/yr)**	Wood Removed From Forest Clearing **(tons dm/yr)**	Net Biomass Consumption **(tons dm/yr)**	Carbon Fraction of Dry Matter **(tons C/ton dm)**	Annual Carbon Released **(tons C/yr)**
FORESTED LAND										
Hardwood	56130000	0.016	898080	747375	1255	1646710	10068.5	1636641.5	0.498	815047.467
Softwood	33584000	0.016	537344	646981	397	1184722	11087	1173635	0.521	611463.835

(tons C/yr)

TOTAL CARBON RELEASED = **1426511.3**

Table A-V.1 Land Use Sector
Change In Forest Use and Woody Biomass Stock

Column A: Area of Biomass/Forest Stocks (acres).

Source: U.S.D.A. Soil Conservation Service, 1992 National Resource Inventory, Summary Report, Table 1, Page 9.

Column A-1: Number of Trees (trees).

Source: MacPherson, Gregory, Rowntree A eds. 1994, Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project, Page 7.

Column B: Annual Growth Rate (tons dry matter/acre/year).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 10-5.

Column C: Annual Biomass Increment (tons dry matter/year).

Source: [Column A (acres)] x [Column B (tons dry matter/acre/year)] = Column C

Column D: Carbon Fraction of Dry Matter (tons C/ton dry matter).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table Page 10-27.

Column D-1: Carbon Fraction of Trees (tons C/tree/year).

Source: MacPherson, Gregory, Rowntree A eds. 1994, Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project, Page 210.

Notes: Chicago's study estimated that 155,000 tons of carbon are sequestered per year from roughly 50,800,000 trees (tons C/tree/year value derived from this study).

Column E: Total Carbon Uptake Increment (tons C/year).

Source: [Column C (tons dry matter/year)] x [Column D (tons C/ton dry matter)] = Column E

Column E-1: Total Carbon Uptake Increment (tons C/year).

Source: [Column A-1 (trees)] x [Column D-1 (tons C/tree/year)] = Column E-1

Column F: Commercial Timber Harvested (cu ft/year).

Source: Thomas S. Frieswyk and Anne M. Malley, Forest Statistics for New Hampshire, 1973 & 1983, USDA Forest Service Northeast Station, Table 2.

Column G: Biomass Conversion/Expansion Ratio (tons dry matter/cu ft).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, page 10-5.

Column H: Total Biomass Removed in Commercial Harvest (tons dry matter/year).

Source: [Column F (cu ft/year)]x [Column G (tons dry matter/cu ft)] = Column H

Column I: Fuelwood Consumed (tons dry matter/year).

Source: Total fuelwood consumed is computed in Table A-I.2, fractions for hardwood and softwood are 0.536 and 0.464 respectively.

Column J: Total Other Wood Used (tons dry matter/year).

Source: Thomas S. Frieswyk and Anne M. Malley, Forest Statistics for New Hampshire, 1973 & 1983, USDA Forest Service Northeast Station, Page 41.

Column K: Gross Biomass Consumed (tons dry matter/year).

Source: [Column H (tons dry matter/year)] + [Column I (tons dry matter/year)] + [Column J (tons dry matter/year)] = Column K

Column L: Wood Removed From Forest Clearing (tons dry matter/year).

Source: Computed as Column G, Table A-V.2, Annual Loss of Biomass as Firewood.

Column M: Net Biomass Consumption (tons dry matter/year).

Source: [Column K (tons dry matter/year)] - [Column L (tons dry matter/year)] = Column K

Column N: Carbon Fraction of Dry Matter (tons C/ton dry matter).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Birdsey Table 1.2.

Column O: Annual Carbon Released (tons C).

Source: [Column M (tons dry matter/year)] x [Column N (tons C/ton dry matter)] = Column O

Table A-V.2

Land Use Sector
Forest and Grassland Conversion

	A	B	C	D	E	F	G	H	I
	Annual Area Converted **(acres/yr)**	Above-Ground Biomass Density Before Conversion **(tons dm/acre)**	Above-Ground Biomass Density After Conversion **(tons dm/acre)**	Net Change In Biomass Density **(tons dm/acre)**	Annual Loss Of Above-Ground Biomass **(tons dm/yr)**	Fraction Of Biomass Used As Firewood	Amount Of Annual Loss Of Biomass Used As Firewood **(tons dm/yr)**	Carbon Fraction Of Above-Ground Biomass **(tons C/ton dm)**	Carbon Released From Loss Of Above-Ground Biomass **(tons C/yr)**
ABOVE-GROUND CARBON RELEASED									
Hardwood	273.6	78.1	4.5	73.6	20136.96	0.5	10068.48	0.521	10491.35616
Softwood	236.9	98.1	4.5	93.6	22173.84	0.5	11086.92	0.498	11042.57232

TOTAL ABOVE-GROUND CARBON RELEASED = **21,534**

Loss of Below-Ground Carbon (Worksheet 10-3,4)

	A-1	B-1	G-1	H-1	I-1
	Annual Area Converted **(acres/yr)**	Carbon Content Density Before Conversion **(tons dm/acre)**	Total Annual Potential Soil Carbon Losses **(tons C/yr)**	Fraction Of Carbon Released Over 25 Years	Carbon Released From Soils **(tons C/yr)**
BELOW-GROUND CARBON RELEASED					
Hardwood	273.6	53.5	14637.6	0.58	8489.808
Softwood	236.9	53.5	12674.15	0.58	7351.007

(tons C/yr)

TOTAL BELOW-GROUND CARBON RELEASED = **15840.815**

(tons C/yr)

TOTAL CARBON RELEASED FROM FOREST AND GRASSLAND CONVERSION = **37374.74348**

Table A-V.2 Land Use Sector
Forest and Grassland Conversion Stock

Column A: Annual Area Converted (acres).

Sources: Thomas S. Frieswyk and Anne M. Malley, Forest Statistics for New Hampshire, 1973 & 1983, USDA Forest Service Northeast Station, Resource Bulletin NE-88.

U.S.D.A. Soil Conservation Service, 1992 National Resource Inventory, Summary Report, July 1994.

Notes: The total acres per year converted was computed to be 510.5. Fractions for hardwood and softwood are 0.536 and 0.464 respectively.

Column A-1: Annual Area Converted (acres).

Sources: Thomas S. Frieswyk and Anne M. Malley, Forest Statistics for New Hampshire, 1973 & 1983, USDA Forest Service Northeast Station, Resource Bulletin NE-88.

U.S.D.A. Soil Conservation Service, 1992 National Resource Inventory, Summary Report, July 1994.

Notes: The total acres per year converted was computed to be 510.5. Fractions for hardwood and softwood are 0.536 and 0.464 respectively.

Column B: Above-Ground Biomass Density Before Conversion (tons dry matter/acre).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Tables 10-3.

Column B-1: Carbon Content Density Before Conversion (tons dry matter/acre).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Tables 10-4.

Column C: Above-Ground Biomass Density After Conversion (tons dry matter/acre).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Page 10-8 (see also errata sheet).

Column D: Net Change In Biomass Density (tons dry matter/acre).

Source: [Column B (tons dry matter/acre)] - [Column C (tons dry matter/acre)] = Column D

Column E: Annual Loss of Above-Ground Biomass (tons dry matter/year).

Source: [Column A (acres/year)] x [Column D (tons dry matter/acre)] = Column E

Column F: Fraction of Biomass Used As Firewood (percentage).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Birdsey Table 1.2.

Column G: Amount of Annual Loss Of Biomass Used As Firewood (tons dry matter/year).

Source: [Column E (tons dry matter/year)] x [Column F (%)] = Column G

Column G-1: Total Annual Potential Soil Carbon Losses (tons C/year).

Source: [Column A-1 (acres/year)] x [Column B-1 (tons dry matter/acre)] = Column G-1

Column H: Carbon Fraction Of Above-Ground Biomass (tons C/ton dry matter).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Birdsey Table 1.2.

Column H-1: Fraction Of Carbon Released Over 25 Year (percentage).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 10-6.

Column I: Carbon Released From Loss Of Above-Ground Biomass (tons C/year).

Source: [Column E (tons dry matter/year)] x [Column H (tons C/ton dry matter)] = Column I

Column I-1: Carbon Released From Soil (tons C/year).

Source: [Column G-1 (tons C/ton dry matter)] x [Column H-1 (%)] = Column I-1

Table A-V.3

Land Use Sector
Abandoned Lands

	A	B	C	D	E
	Area Abandoned And Regrowing **(acres)**	Annual Rate Of Above-Ground Biomass Growth **(tons dm/acre/yr)**	Annual Rate Of Above-Ground Biomass Growth **(tons dm/yr)**	Carbon Fraction Of Above-Ground Biomass **(tons C/tons dm)**	Annual Carbon Uptake In Above-Ground Biomass **(tons C/yr)**
ABOVE-GROUND CARBON UPTAKE					
Hardwood	1608	0.89	1431.12	0.521	745.61352
Softwood	1392	1.3	1809.6	0.498	901.1808

	A-1	B-1	E-1
	Area Abandoned And Regrowing **(acres)**	Annual Uptake Of Carbon In Soils **(tons C/acre/yr)**	Annual Carbon Uptake In Soils (tons C/yr)
BELOW-GROUND CARBON UPTAKE			
Hardwood	1608	0.58	932.64
Softwood	1392	0.58	807.36

(tons C/yr)

TOTAL ABANDONED LAND CARBON UPTAKE = **3,387**

Table A-V.3 Land Use Sector
Abandoned Lands

Column A: Area Abandoned and Regrowing (acres).

Sources: NH Department of Resources and Economic Development, phone conversation with J.B. Cullen, July 27, 1995.

Notes: The total acres per year abandoned and allowed to regrow was estimated to be 3,000. Fractions for hardwood and softwood are 0.536 and 0.464 respectively.

Column A-1: Area Abandoned and Regrowing (acres).

Sources: NH Department of Resources and Economic Development, phone conversation with J.B. Cullen, July 27, 1995.

Notes: The total acres per year abandoned and allowed to regrow was estimated to be 3,000. Fractions for hardwood and softwood are 0.536 and 0.464 respectively.

Column B: Annual Rate Of Above-Ground Biomass Growth (tons dry matter/acre/year).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 10-5.

Column B-1: Annual Uptake of Carbon In Soils (tons C/acre/year).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Table 10-6.

Column C: Annual Rate Of Above-Ground Biomass Growth (tons dry matter/year).

Source: [Column A (acres)] x [Column B (tons dry matter/acre/year)]= Column C

Column D: Carbon Fraction Of Above-Ground Biomass (tons C/ton dry matter).

Source: U.S.E.P.A. State Workbook: Methodologies for Estimating Greenhouse Gas Emissions, Second Edition, 1995, Birdsey Table 1.2.

Column E: Annual Carbon Uptake In Above-Ground Biomass (tons C/year).

Source: [Column C (tons dry matter/year)] x [Column D (tons C/ton dry matter)] = Column E

Column E-1: Annual Carbon Uptake In Soils (tons C/year).

Source: [Column A-1 (acres)] x [Column B-1 (tons C/acre/year)]= Column E-1

Table A-V.4

Land Use Sector
Natural Methane Production In Wetlands

	A	B	C	D	E	F	G	H
	Wetlands Area (1992) **(acres)**	Wetlands CO2 Adsorption Factor **(lbs CO2/acre/yr)**	Total CO2 Adsorption **(tons CO2/yr)**	Total CO2 Adsorption GWP = 1.0 **(CO2 TCDE)**	Wetlands CH4 Production Factor **(lbs/acre/yr)**	Total CH4 Production **(tons CH4/yr)**	Total CH4 Production GWP = 24.5 **(CO2 TCDE)**	Net Annual Wetlands GHG Emission* **(TCDE)**
ABOVE-GROUND CARBON UPTAKE								
Hardwood	710200	753	267390.3	267390.3	71	25212.1	617696.45	350306.15

* Net Annual Greenhouse Gas Emissions from wetlands are tabulated but are not included in the inventory.

Table A-V.4 Land Use Sector
Natural Methane Production In Wetlands

Column A: Wetlands Area, 1992 (acres).

Sources: U.S.D.A. Soil Conservation Service, Summary Report: 1992 National Resources Inventory, July 1994, Table 17.

Notes: Includes all wetland and deep water habitats on non-federal land and water areas.

Column B: Wetland Carbon Dioxide Adsorption (lbs CO_2/acre/year).

Sources: S. Frolking, 1993, Regional Freshwater Wetlands and Their Trace Gas Exchange with the Atmosphere (In proceedings of "A Regional Response to Global Climate Change: New England and Eastern Canada", Portland, ME).

Notes: This value represents the average flux of CO_2 in wetland systems.

Column C: Total CO_2 Adsorption (tons CO_2/year).

Source: [Column A (acres)] x [Column B (lbs CO_2/acre/year)] ÷ [2,000 lbs/ton] = Column C

Column D: Total CO_2 Adsorption (TCDE).

Source: [Column C (tons CO_2/year)] x [GWP of CO_2 (1.0)] = Column D

Column E: Wetland CH_4 Production Factor (lbs CH_4/acre/year).

Sources: S. Frolking, 1993, Regional Freshwater Wetlands and Their Trace Gas Exchange with the Atmosphere (In proceedings of "A Regional Response to Global Climate Change: New England and Eastern Canada", Portland, ME).

Notes: This value represents the average flux of CO_2 into CH_4.

Column F: Total CH_4 Production (tons CH_4/year).

Source: [Column A (acres)] x [Column E (lbs CH_4/acre/year)] ÷ [2,000 lbs/ton] = Column F

Column G: Total CH_4 Production (TCDE).

Source: [Column F (tons CH_4/year)] x [GWP of CH_4 (24.5)] = Column G

Column H: Net Annual Wetlands GHG Emission (TCDE).

Source: [Column G (TCDE)] - [Column D (TCDE)] = Column H

Notes: Wetlands net methane emissions are tabulated but are not calculated in the GHG inventory.

Table A-V.5

Land Use Sector
Total Net Carbon, CO2 Uptake

	A	B	C	D
	Changes In Forest And Woody Biomass Stock **(tons Carbon)**	Forest And Grassland Conversion **(tons Carbon)**	Abandoned Lands **(tons Carbon)**	Total **(tons Carbon)**
TOTAL CARBON UPTAKE	2793933	0	3387	2797320
TOTAL CARBON RELEASED	1426511	37375	0	1463886

	(tons Carbon)
NET CARBON UPTAKE	**1333434**
	(tons CO2)
NET CO2 (44/12) UPTAKE	**4889258**
	(TCDE)
NET CO2 UPTAKE (GWP = 1.0)	**4889258**

Table A-V.5 Land Use Sector
Total Net Carbon, CO2 Uptake

Column A: Changes In Forest and Woody Biomass Stock (tons Carbon).

Sources: Table A-V.1

Column B: Forest and Grassland Conversion (tons Carbon).

Sources: Table A-V.2

Column C: Abandoned Lands (tons Carbon).

Sources: Table A-V.3

Column D: Total (tons Carbon).

Source: [Column A (tons Carbon)] + [Column B (tons Carbon)] + [Column C (tons Carbon)] = Column D

New Hampshire
1993
Greenhouse Gas Inventory

Glossary of Terms

Aerobic - with oxygen present. With regard to decomposition processes, aerobic conditions indicate that organic matter will be completely degraded into its components (mainly CO2 and water). Little methane is emitted in aerobic decomposition.

Anaerobic - without oxygen. Without oxygen decomposers are not able to degrade organic matter completely to CO2 and water. Intermediate products accumulate such as methane and alcohols. These products often create a bad odor.

Augmented Greenhouse Effect - When greenhouse gas concentrations in the atmosphere are raised above natural levels, the Greenhouse Effect is magnified resulting in global warming and other global climate changes. Human activity in the past 200 years has caused this Augmented Greenhouse Effect.

Biomass - in this report, biomass refers to living organic matter. Organic matter always contains carbon.

Bituminous Coal - anthracite, or black coal.

B.O.D. - Biological oxygen demand (BOD) is an indicator of the amount of C in water. Technically, it is the amount of oxygen required to decompose an organic pollutant.

Btu - British Thermal Unit. It is a measure of energy. 1 Btu = 252 calories or 1055 joules.

Distillate Oil - light oils, these are the oils that are distilled from crude oil. Used for home heating oil, water heaters. Gasoline is also a type of distillate oil but is considered separately in this inventory.

Emission - in this report the production and transfer of a greenhouse gas to the atmosphere over and above natural greenhouse gas fluxes. Emissions contribute to the Augmented Greenhouse Effect.

Fossil fuel - namely oil, coal, tar sands, oil shales and natural gas. These fuels are the remains of living organisms that have been transformed by the high temperatures and pressures in the earth=s crust.

Greenhouse Effect - The natural mechanism in the Earth=s atmosphere that slows down the loss of heat from the surface of the Earth to outer space. The Greenhouse Effect is essential to life of earth. It is caused by low concentrations of greenhouse gases in the atmosphere that absorb heat energy.

Greenhouse gas - any of several gases that absorb heat energy. Naturally occurring greenhouse gases are water vapor, CO2, methane, nitrous oxide and ozone. Human-made greenhouse gases are chlorofluorocarbons (CFCs).

LPG - liquefied petroleum gas. Gaseous petroleum by-products, mainly propane and butane, that are held under pressure in liquid form.

Production - In this report, production of a greenhouse gas (in contrast to emission) does not contribute to the Augmented Greenhouse Effect because it is generated by a natural source or is generated from renewable C sources.

Residual Oil - heavy oils, these are the oils remaining after the distillation process. These are used as fuels in larger Industrial and Commercial operations.

Ruminant - namely cattle, deer and camels. These animals have a four-chambered stomach that allows them to digest extremely course and low nutrient forages such as grass and straw. Their unique digestive pathway produces large amounts of methane.

Sink - in biogeochemical terms, a sink is something that stores or sequesters an element. It removes it from circulation.

Source - in biogeochemical terms, a source is something that releases or produces an element. It adds it to the circulating flux.

TTCDE - thousand tons carbon dioxide equivalent. Common units for global warming potential of greenhouse gases.