CHAPTER 7
WASTES AND FORESTS SECTORS

Introduction

Efforts to reduce GHG emissions through waste reduction and efforts to increase the carbon sequestration rates of forest sinks are cross-sectoral in nature, encompassing the activities of all sectors of the society (i.e., residential, commercial, transportation, and industrial). A comprehensive response to climate change must include initiatives to reduce greenhouse gas emissions through better waste management and to sequester CO_2 by expanding forest sinks.

Waste reduction and sink improvements are discussed below in separate sections. For each section, an overview is first presented, followed by a description of the sources and trends of emissions/carbon sequestration and the current status of policy in Delaware. In the final section of the chapter, the results of the Action Plan concerning this sector are summarized.

WASTES SECTOR
EMISSION REDUCTION STRATEGY

Key Findings

Figure 7-1

Wastes Sector CO_2 Emission Projections Through 2010

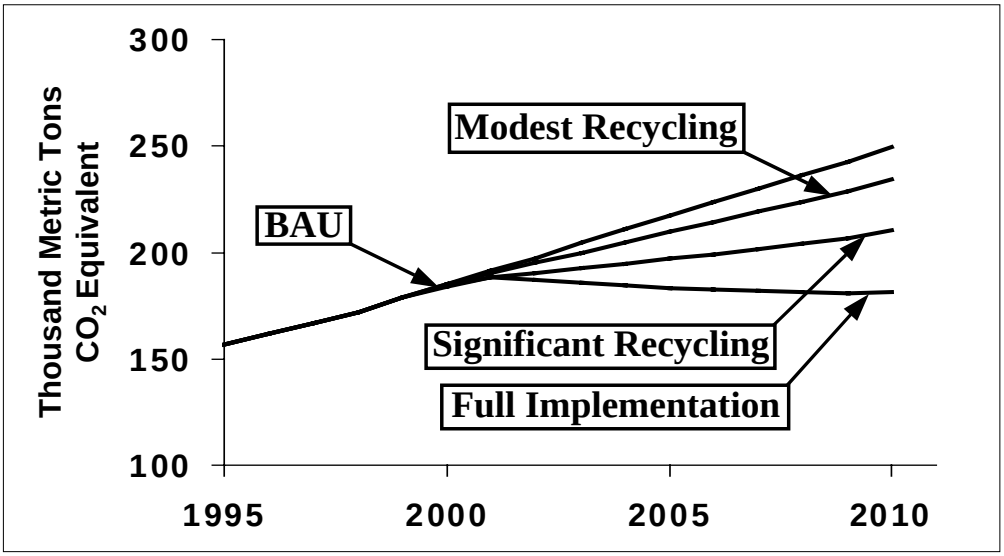

Table 7-1

Results from Projected Waste Reduction Scenarios

Scenarios	GHG Emissions ($mtCO_2$ equivalent)	Percent Reduction in Emissions
1995	156,720	NA
2010 (BAU) Scenario	249,840	NA
Modest Recycling Scenario	234,570	6.11%
Significant Recycling Scenario	210,159	15.88%
Full Potential Waste Reduction Scenario	181,362	27.41%

The CO_2 equivalent emissions from municipal waste are projected in the business-as-usual (BAU) scenario to increase steadily through 2010. Three alternative recycling scenarios are considered to reduce the waste stream. Each of these scenarios allows a reduction in CO_2 equivalent emissions in 2010 compared to the BAU projection. These results are reported in Table 7-1 and are illustrated in Figure 7-1.

Background

The two primary greenhouse gases emitted from municipal waste are methane (CH_4) and carbon dioxide (CO_2). Both CH_4 and CO_2 are produced by the decomposition of organic wastes in the anaerobic environment of landfills.[1]

The Solid Waste Management Branch of the Division of Air & Waste Management in Delaware's Department of Natural Resources and Environmental Control (DNREC) regulates the management of solid waste in Delaware. This branch also oversees the solid waste reduction, reuse, and recycling programs in the State. Title 7, Chapter 64 of the Delaware Code, in 1975, designated the Delaware Solid Waste Authority (DSWA) the sole entity with responsibility for planning and implementing solid waste management throughout Delaware. DSWA receives 100% of the solid waste generated from state, county and municipal facilities, and residential communities. Major industries in Delaware must have their own private waste disposal facilities.[2]

There are currently three DSWA landfills active in Delaware — Cherry Island Landfill (CIL), the Central Solid Waste Management Center (CSWMC), and the Southern Solid Waste Management Center (SSWMC). The Pigeon Point Landfill (PPLF) was closed in 1985, but still emits both CH_4 and CO_2. These four landfills contain only municipal solid waste (MSW) taken from the residential and commercial sectors.

Data used to analyze MSW in Delaware were provided by DSWA. The U.S. Environmental Protection Agency (USEPA) Landfill Gas Emissions Model Version 2.01

[1] The organic materials responsible for CH_4 emissions include yard waste, household garbage, food waste, and paper. When deposited in landfills, these organic materials decompose aerobically (in the presence of oxygen), and are then attacked by anaerobic bacteria and converted into substances such as cellulose, amino acids, and sugars. These substances are further broken, through a series of processes, into stabilized organic materials and a biogas (50% CO_2 and 50% CH_4 by volume — see USEPA, http://www.epa.gov/globalwarming/inventory).

[2] There are seven industrial landfills in Delaware. Delaware Recyclable Products, Inc. operates one site holding its waste. Conectiv, the state's largest electric utility, manages two sites holding its ash waste. The DuPont Company manages two sites holding its sludge and ash wastes. Star Enterprises also manages two sites that contain its sludge and ash wastes (DNREC, http://www.dnrec.state.de.us).

was used to calculate the CO_2 equivalent emissions for both the BAU and the three alternative scenarios (discussed below).

Sources and Trends of Emissions

In 1990, 266 million metric tons of municipal solid waste (MSW) were generated in the U.S. (USEPA 1998), 71% of which were disposed in landfills (*Biocycle* 1997). Landfills account for approximately 36% of the total CH_4 emissions in the country, making them the largest anthropogenic source (USEPA 1999). In the U.S., MSW landfills account for about 93% of the total landfill emissions, while industrial landfills account for the remaining 7% (USEPA 1999). Of the more than 6,000 landfills throughout the country, the 1,300 largest sites receive over 50% of the waste and generate most of the landfill-attributed emissions (USEPA 1999).

Delaware's CO_2 equivalent emissions (these include CH_4 releases calculated in CO_2 equivalent units), since 1966, have generally increased. The annual additions of waste at each of the four landfills have increased emissions, while recent CH_4 flaring has decreased CH_4 emissions.[3] Therefore, for a brief period in the late 1980s and early 1990s, emissions decreased due to the CH_4 flaring by DSWA. Delaware currently landfills 63.7% of the total solid waste generated in the State, while 33.7% is incinerated and 2.5% is recycled (Drew Sammons, DSWA).

Projections

The BAU scenario was developed in order to project CO_2 equivalent emissions in the event that no additional efforts were made to reduce the amount of waste entering landfills. This scenario assumes that 2.5% of the total MSW stream will continue to be recycled until 2010 through DSWA's Recycle Delaware program. The percentage of material landfilled and incinerated was also assumed to remain the same under the BAU

[3] PPLL opened in 1966 and began flaring in 1988; CSWMC opened in 1982 and began flaring in 1990; CIL opened in 1986 and began flaring in 1990; and SSWMC opened in 1986 and began flaring in 1994.

scenario, while the total amount of MSW is assumed to steadily increase in proportion to the growth in Delaware's population.

In 1995, 156,718 $mtCO_2(e)$ were emitted from the CIL, CSWMC, SSWMC, and PPLF landfills. Under the BAU scenario, these four landfills are projected to emit 249,840 $mtCO_2(e)$[4] in 2010.

Current Status of Policy in Delaware

The State of Delaware has enacted three separate policies to address waste management issues (DSWA 1994):

- Bi-County Recycling Project (1988), which directed DSWA to implement a Material and Energy Recovery Program for Kent and Sussex Counties;
- Program for Infectious Waste (1989), a project which directed DSWA to implement a statewide infectious waste management program; and
- Recycling and Waste Reduction Project (1990), which directed DSWA to implement a statewide recycling and waste reduction program.

There is currently no incineration in the State of Delaware. The 33.7% of MSW generated in Delaware that is incinerated is contracted out to Chester, Pennsylvania.

Recycle Delaware operated by DSWA as a result of the 1990 law, provides Delawareans with voluntary drop-off points for recyclable materials across the state. Delaware does not have a mandatory recycling laws. In 1995, New Jersey recycled approximately 60% of its total solid waste generated, in part due to a mandatory recycling law. New Jersey has established a goal of recycling 65% of its solid waste by December 31, 2000 (New Jersey Bureau of Recycling and Planning 1999).

[4] The CO_2 equivalent measurement includes the CH_4 and the CO_2 emitted from the four landfills, as well as the CO_2 emitted as a by-product of CH_4 flaring.

There has been an effort in Delaware to implement market-based policies that reduce the amount of waste received by landfills. For example, the Delaware Economic Development Office (DEDO) and the Department of Natural Resources and Environmental Control (DNREC) have embarked upon a Green Industries Initiative to promote the use of recycled materials and increased recycling of waste generated within Delaware's manufacturing sector through corporate tax credits and reductions in the gross receipts tax for source reduction and recycling activities.

Methodology

The Action Plan utilized the USEPA Landfill Gas Emissions Model Version 2.01 to calculate both the CH_4 and the CO_2 emissions from the four active landfills in Delaware (CIL, CSWMC, SSWMC, and PPLF) for the BAU and the three alternative scenarios. In order to estimate annual CH_4 and CO_2 landfill emissions, the amount of refuse in place for each of the four active landfills was entered into the model. Actual data were used through 1998. Projections were made to 2010 based upon Delaware population projections. In a second step, CO_2 emissions from DSWA's CH_4 flaring process were estimated. Flaring reduces the amount of CH_4 that enters the atmosphere, while at the same time emits additional amounts of CO_2. The final step is to sum the amount of CH_4 emitted from the landfills after flaring, the amount of CH_4 emitted from the landfills, and the amount of CO_2 released during the flaring process. See Appendix O for a detailed account of the methodology used.

Analysis of Options

Recycling was the primary measure evaluated in the Action Plan to promote waste reduction. Three scenarios were explored, each of which projected the results of additional recycling efforts in the MSW management program in Delaware. These three scenarios are further described in Appendix P.

Modest Recycling Scenario

The Modest Recycling scenario assumes that the percentage of the MSW stream recycled through DSWA's Recycle Delaware program will gradually increase to 15% in 2001 (5% in 1999, 10% in 2000) and remain at 15% until 2010. An increase in the percent recycled will be accompanied by a corresponding decrease in the amount of material landfilled, while the incineration rate is assumed to remain the same. This scenario anticipates that DSWA achieves less than half of its goal of recycling 35% of Delaware's waste stream by 2001.

Significant Recycling Scenario

The Significant Recycling scenario reflects DSWA's goal of recycling 35% of the MSW stream through its Recycle Delaware program in 2001 (seen as a gradual increase from 10% in 1999 to 20% in 2000 and 35% in 2001 — see DSWA, 1994).

Full Potential Waste Reduction Scenario

The Full Implementation scenario also reflects DSWA's goal of recycling 35% of the total MSW stream through Recycle Delaware (i.e., 25% residential and 10% nonresidential). However, this scenario anticipates an additional 25% recycling rate in 2001 due to the implementation of a Pay-As-You-Throw (PAYT)[5] program in Delaware (USEPA 1997). Thus, in 2001, 60% of the MSW stream is expected to be recycled and consequently diverted from the State's four landfills. This rate of recycling would put Delaware roughly at parity with New Jersey.

Results

Each of the three scenarios leads to reductions in CO_2 equivalent emissions from the BAU projections. Under the Modest Recycling scenario, the four landfills are projected to emit 234,570 mtCO_2(e) in 2010. This represents a 6% (15,270 mt) reduction from CO_2 equivalent emissions projected under the BAU for 2010. Under the Significant

[5] Instead of paying for trash collection and disposal indirectly, the PAYT program prices each unit of trash separately. This gives an incentive for individuals and communities to reduce the amount of waste sent to landfills and to incineration (USEPA 1997).

Recycling scenario, these same four landfills are projected to emit 210,159 mtCO_2(e) in 2010. This represents a 16% (39,681 mt) reduction from the BAU projection for 2010. Under the Full Implementation scenario, the four landfills are projected to emit 181,362 mtCO_2(e) in 2010. This represents a 27% (68,478 mt) reduction from the BAU projection for 2010.

Given the current recycling situation in Delaware (2.6% of the MSW stream is recycled), the three alternative scenarios represent major shifts from the BAU. Obviously, new policies will be needed to realize such targets. Specific policy recommendations are identified in the final chapter of the Action Plan.

FORESTS SECTOR
CARBON SEQUESTRATION STRATEGIES

Key Findings

Figure 7-2

CO_2 Sequestration Capacity Through 2010 for Delaware's Forest Sinks

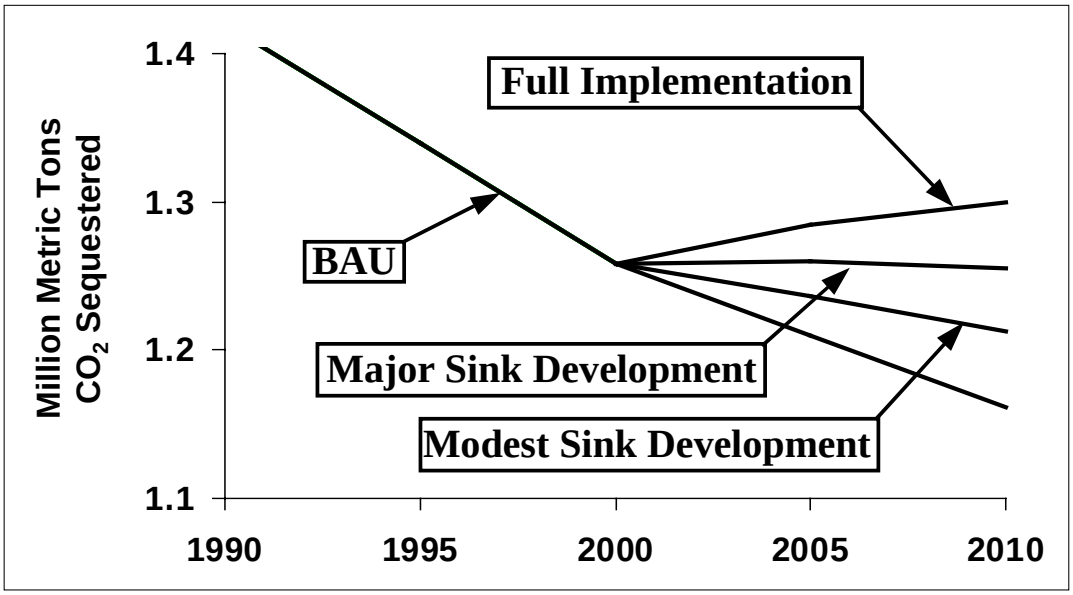

Table 7-2

Results from Projected Carbon Sequestration Strategies for Delaware's Forest Sinks

Scenarios	CO_2 Sequestered in 2010(mt)	Increase from BAU in 2010
1990	1,420,000	NA
2010 BAU	1,161,242	NA
Modest Sink Development	1,212,207	4.4%
Advanced Sink Development	1,255,478	8.1%
Full Implementation	1,299,842	11.9%

Carbon sequestration is projected in the BAU case to decrease steadily from 1990 to 2010. Three alternative forest sink development scenarios are evaluated. Each of these

scenarios shows an increase of CO_2 sequestered in 2010 compared to the BAU projection. These results are reported in Table 7-2 and are illustrated in Figure 7-2.

Background

Carbon sinks such as forestlands, wetlands, croplands, pasturelands and bodies of water[6] play a critical role in the reduction of GHG emissions. USEPA estimates that the annual net CO_2 flux in U.S forests offset about 14 % of the 1996 CO_2 emissions from fossil fuel combustion (USEPA 1998). In the State of Delaware, forests and wetlands are the primary carbon sinks.

Sources and Trends of Carbon Sequestration

Table 7-3 reports the aggregate land use and land cover changes of the state of Delaware in 1984 and in 1992. The preliminary estimates of Mackenzie and McCullough (1998) indicate a 9% decrease in forest acreage in Delaware between 1984 and 1992. Except for wetlands, the acreage of other potential sinks of Delaware also reduced. The USDA Forest Service inventory in 1992 indicates that 95.89 % of Delaware's forestlands were owned privately (See Table 7-4).[7] From 1992 to 1998, Delaware lost forestlands at a rate of 5,667 acres per year.[8]

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[6] The global carbon cycle is made up of large carbon flows and reservoirs. Billions of tons of carbon in the form of CO_2 are absorbed by the oceans or terrestrial sinks (forests and agricultural systems) or are emitted to the atmosphere annually through natural processes (USEPA 1998). As carbon reservoirs, terrestrial sinks store carbon mostly in soils. For instance, in forests ecosystems, 61% of stored carbon is found in forest soils, 29% in trees, and the remaining 10% in woody litter, debris and humus on the forest floor as well as understory vegetation (STAPPA/ALAPCO 1998). In agricultural systems such as croplands (soil sinks), CO_2 is stored as soil organic carbon (SOC). Wetlands also produce high rates of organic carbon accumulation, ten times as much organic soil carbon (OSC) as their more well-drained counterparts (Rabenhorst 1995).

[7] Mackenzie & McCullough's estimate (1998) is slightly lower than that of the USDA Forest Service. The discrepancy might be attributed to the fact that Mackenzie & McCullough did not include some wetlands which were forested (Austin Short, Delaware Department of Agriculture, personal communication).

[8] Using USDA Forest Service estimates of Delaware's forestlands in 1992 (389,000 acres) and the estimated acreage of Delaware's forestlands in 1998 (355,000 acres), the State lost forest areas at a rate of 5,667 acres per year or about 1.5 % annually between 1992 and 1998.

Table 7-3

Delaware Land-Use/Land Cover Changes, 1984 & 1992

	1984 Area (Acres)	Percent	1992 Area (Acres)	Percent
Residential	80,996	6.3%	120,808	9.4%
Commercial/Industrial	37,044	2.9%	59,356	4.6%
Recreation	8,045	0.6%	8,811	0.7%
Agriculture	599,109	46.7%	560,479	43.7%
Brushland	43,870	3.4%	22,957	1.8%
Forest *	380,684	29.7%	345,778	27.0%
Water	31,363	2.5%	46,275	3.6%
Wetland	96,077	7.5%	101,284	7.9%
Beach/Barren	3,684	0.3%	17,141	1.3%
Total	1,280,872	100.0%	1,282,887	100.0%

*Includes deciduous, coniferous, and mixed forests.
Source: Mackenzie, J. and McCullough (1998).

Table 7-4

Forest Land Area in Delaware and the U.S. by Ownership, 1992

	Delaware (1000 acres)	Percent	Total U.S. (1000 acres)	Percent
Public Forest				
Forest Service			139,944	19.0%
Other Federal *	2	0.5%	109,187	14.8%
Other Public	14	3.6%	64,747	8.8%
Total Public Lands	16	4.1%	313,878	42.6%
Private Forests				
Forest Industry	31	8.0%	71,209	9.7%
Other Private	342	87.9%	352,546	47.8%
Total Private Forests	373	95.9%	423,755	57.5%
Total Forest Lands	**389**	**100.0%**	**737,633**	**100.0%**

*Includes Bureau of Land Management, U.S. Park Service, U.S. Department of Defense and all other Federal ownership.
Source: USDOA Forest Service (1992).

Current Status of Policy in Delaware

The existing mix of economic incentives, regulation, and non-economic and voluntary programs of the State regarding carbon sinks (See Appendix Q) aim to achieve three interrelated goals:

(1) decrease the rate of loss of existing Delaware forest sinks (e.g., Delaware's Open Space Program);
(2) expand the storage base of Delaware forest sinks (e.g., Delaware Seed Tree Law and Delaware Forestry Practices Erosion and Sediment Law);
(3) support a reduction in energy demand through urban landscaping (e.g., Urban and Community Tree Planting Grants).

Delaware's Open Space Program[9] has helped to preserve 13,000 acres of land, and the Northern Delaware Rehabilitation Program restored nearly 10,000 acres of wetlands along the Christiana and Delaware Rivers in New Castle County. It is also estimated that 2,100 acres are reforested annually and another 1,700 acres are regenerated naturally (Abbott-Donnelly and Short, Delaware Department of Agriculture, personal communications). In 1998, considering reforestation and natural regeneration in the accounting of net acreage of standing forest, the total net loss of forest lands is 2,725 acres.[1]

In 1991, $530,000 in urban forestry grants was awarded to communities for tree planting and tree maintenance projects. The average cost for planting trees was $140-240

[9] The signing into law of the Land Protection Act (July 13, 1990) and Subchapter II of the Realty Transfer Tax Act created the Delaware Open Space Program. The Division of Parks and Recreation in the Department of Natural Resources and Environmental Control (DNREC) administers the program. Program funds support land preservation activities of DNREC's Division of Parks and Recreation and Fish and Wildlife, the Department of Agriculture's Division of Resource Management and the Department of State's Division of Historical and Cultural Affairs.

[1] The net acreage of standing forest is computed as the sum of the following: acres of existing rural/community/urban forest (355,000 acres) + acres of natural regeneration in open spaces and harvested rural forests (1,700 acres) + acres of artificial regeneration in open spaces and harvested rural forests (2,100 acres) – acres lost due to harvesting of rural forests (5,325 acres) – acres lost due to community/urban development (1,000 acres) – acres lost due to agricultural land conversion (200 acres) (Abbot-Donnelly, personal communication).

per acre.[2] In addition to State programs, the New Castle Conservation District has an urban forest cost-share program that promotes tree planting.

The State programs allow landowners with forested land to claim tax deductions or offer other economic incentives, such as the Commercial Forest Plantation Act and the Farmland Assessment Program. These programs encourage the retention of certain forms of forest cover. A mix of federal and states initiatives include economic incentives for forest protection through the Steward Incentive Program, Forest Incentive Program, Conservation Reserve Program, and Conservation Reserve Enhancement Program. The Delaware Center for Horticulture sponsors tree-planting and conservation easement programs, as well.

Methodology

Delaware's forest and urban tree CO_2 sequestration potential were evaluated. Other sinks were not analyzed due to insufficient data. The total CO_2 sequestered by forests and urban trees is the sum of the CO_2 sequestered by existing and growing forested communities coupled with the CO_2 sequestered by natural and artificial plantings (See Appendix R).

The basic structure of the BAU and the three alternative scenarios are described in Appendix S. There are three measures that are evaluated in each scenario: (1) urban trees planting, (2) harvesting of rural forests, and (3) urban conversion. It is assumed that natural regeneration of forests, artificial regeneration of forests, and annual loss of forests due to agriculture conversion remains constant until 2010.

[2] Austin Short of the Delaware Department of Agriculture has estimated that the cost to plant pine trees per acre is around $140. However, there are sites which needs additional work, and this could add an additional $100 per acre. This estimate does not include an allotment for personnel expenses.

BAU Case

It is assumed that there will be an annual net loss of forest acreage of 2,725 acres through 2010. This loss is projected even while it is assumed that 10,000 trees are planted annually through 2010.

Modest and Major Sink Development Scenarios

These scenarios would increase urban tree planting and slow down rural forest harvesting and urban conversion.

Full Implementation

This scenario would require a halt in urban land conversion through 2010, substantial urban tree planting and a substantial reduction in rural forest harvesting.

Analysis of Options

Table 7-5 shows the amount of CO_2 sequestered by Delaware's forest and urban trees for each scenario from 1990 to 2010. As shown in Figure 7-2, the forecasted decline in Delaware's forest and urban tree CO_2 sequestration capacity is slowed under the Modest Sink Development scenario. The Major Sink Development scenario has the potential to stabilize the declining carbon sequestration capacity between the range of 1.2 to 1.3 mmt. The Full Potential Sink Development scenario, on the other hand, reverses the decline in CO_2 sequestration capacity (See Figure 7-2).

Table 7-5

CO_2 Sequestered in Each Scenario

	Business-as-Usual (mt)	Modest Sink Development (mt)	Major Sink Development (mt)	Full Implementation (mt)
1990	1,420,020	1,420,020	1,420,020	1,420,020
1992	1,400,400	1,400,400	1,400,400	1,400,400
1998	1,278,036	1,278,000	1,278,000	1,278,000
1999	1,268,226	1,271,439	1,274,671	1,277,902
2000	1,258,460	1,265,081	1,271,611	1,278,157
2001	1,248,701	1,258,924	1,268,821	1,278,766
2002	1,238,950	1,252,966	1,266,299	1,279,728
2003	1,229,207	1,247,205	1,264,042	1,281,041
2004	1,219,474	1,241,640	1,262,050	1,282,703
2005	1,209,748	1,236,267	1,260,318	1,284,711
2006	1,200,031	1,231,083	1,258,843	1,287,060
2007	1,190,322	1,226,088	1,257,625	1,289,752
2008	1,180,620	1,2,21,278	1,256,659	1,292,780
2009	1,170,927	1,216,652	1,255,944	1,296,144
2010	1,161,242	1,212,207	1,255,478	1,299,842

Source: Appendix T

Conclusion

Emissions from the wastes sector totaled 156,720 $mtCO_2$ in 1995 and are forecast to rise to 249,840 $mtCO_2$ by 2010 under the BAU scenario. Adopting the Modest Recycling scenario results in emissions of 234,570 $mtCO_2$ in 2010, which can be further lowered using the Significant Recycling scenario to 210,159 $mtCO_2$. Under the Full Implementation scenario for waste reduction, emissions would be 181,362 $mtCO_2$ by 2010. Using the Major Commitment scenario as the benchmark for action, emissions in the wastes sector can be reduced by 16% from the forecast level for 2010.

Sequestration in carbon sinks was 1,420,000 $mtCO_2$ in 1990 and increases to 1,161,242 $mtCO_2$ in 2010 under the BAU scenario. Under the Modest Sink Development scenario, carbon sequestration increases to 1,212,207 $mtCO_2$ at 2010, and increases to 1,255,478 $mtCO_2$ by 2010 using the Major Sink Development scenario. Sequestration can improve to 1,299,842 $mtCO_2$ at 2010 under the Full Implementation scenario. Using

the Major Sink Development scenario as the benchmark for action, emissions in the forest sinks sector can be reduced by 22% from the forecast level for 2010.

The wastes and forest sinks sectors complete the analysis of CO_2 emissions and storage attributable to human activities in Delaware. Whereas the other sectors analyzed for the Action Plan release CO_2 through production or consumption, this sector examines ways to reduce CO_2 releases across the other sectors and to enhance CO_2 absorption.

In terms of waste reduction, measures that cost-effectively reduce or eliminate waste at the source (i.e., source reduction/ resource reduction) are highlighted in the Plan. Measures analyzed to enhance Delaware's forest sink capacity include efforts to curb the amount of land converted for development purposes and increased tree planting. The success of the measures proposed for the wastes and forest sinks sectors will depend upon cooperation among the other sectors (residential, commercial, industrial, utility, and transportation) in meeting the targets identified by the Action Plan.

Waste reduction and forest sinks development offer many benefits in addition to CO_2 reduction/absorption, including improved air quality, enhanced biodiversity, and an overall increase in the quality of life of Delawareans. Specific policy actions to support the adoption of the analyzed measures for CO_2 emission reduction or sequestration are identified in Chapter 9.

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