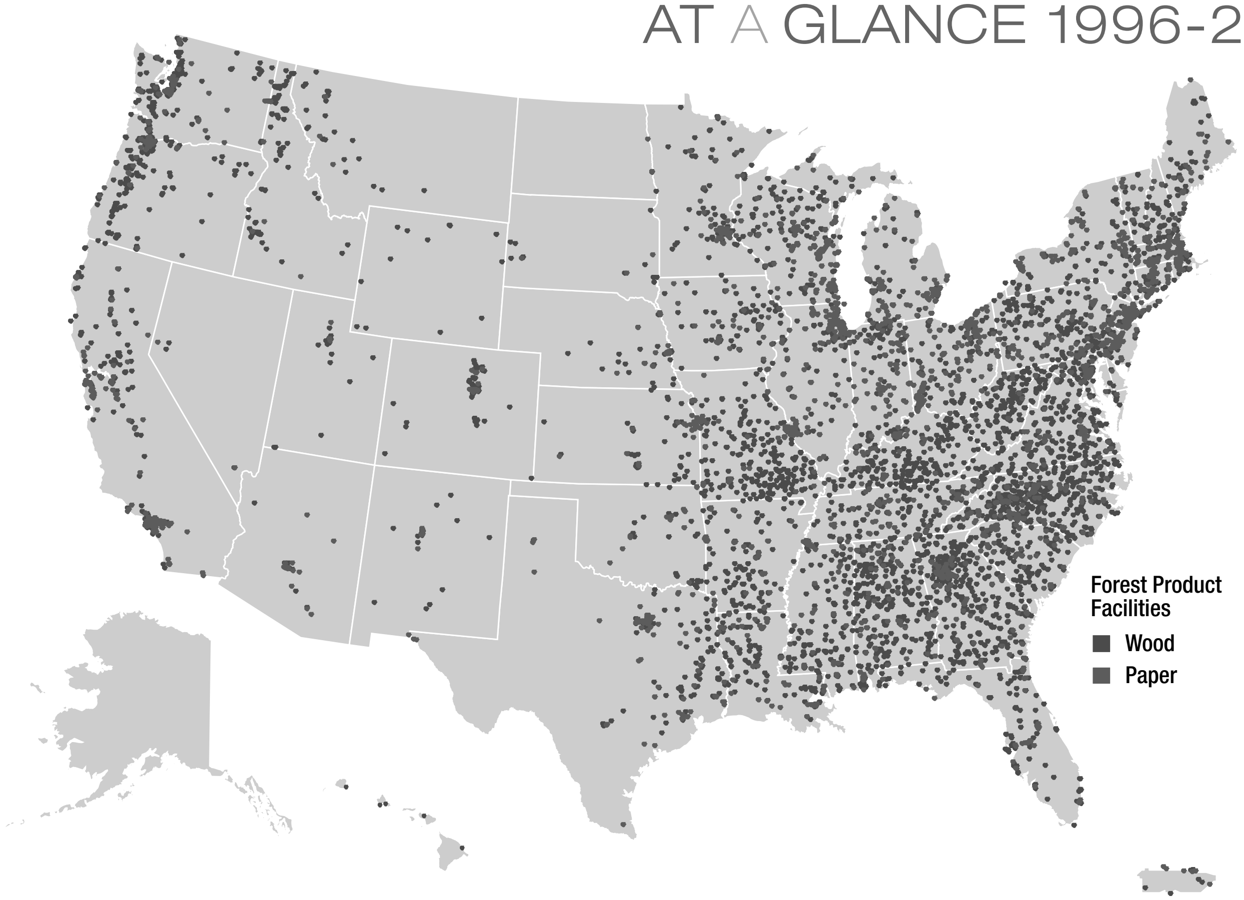
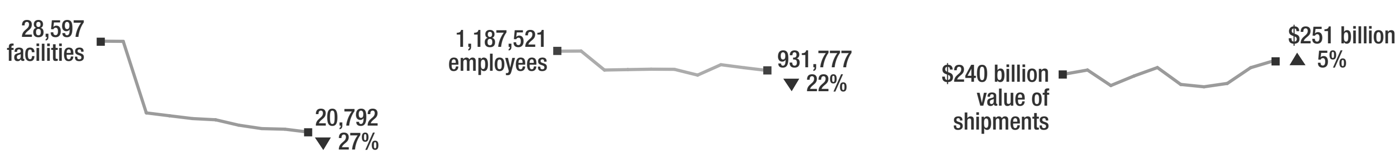
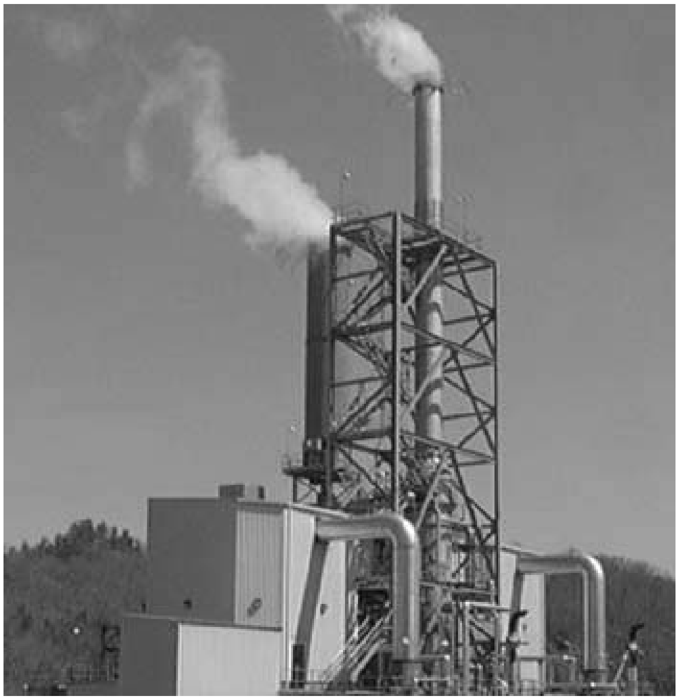
FOREST PRODUCTS

AT A GLANCE 1996-2005[1]







Latest Environmental Statistics[2]

Energy Use: 2.7 quadrillion Btu

Emissions of Criteria Air Pollutants: 1.5 million tons

Releases of Chemicals Reported to TRI: 255.7 million lbs.

Air Emissions: 206 million lbs.

Water Discharges: 20.5 million lbs.

Waste Disposals: 29 million lbs.

Recycling, Energy Recovery, or Treatment: 1.4 billion lbs.

Hazardous Waste Generated: 136,000 tons

Hazardous Waste Managed: 396,000 tons

The data discussed in this report are drawn from multiple public and private sources. See the Data Guide *and the* Data Sources, Methodologies, and Considerations *chapter for important information and qualifications about how data are generated, synthesized, and presented.*

Profile

The Forest Products sector includes firms that manufacture wood pulp, paper, paperboard, and wood products such as lumber.[3]

- Some facilities of the pulp and paper industry process raw wood fiber or recycled fiber to make pulp and/or paper. Other facilities use these primary materials to manufacture specialized products such as paperboard boxes, writing paper, and sanitary paper.
- Companies in the lumber and wood products industry cut timber and pulpwood, mill raw materials into lumber and building materials, and manufacture finished articles such as wood panels.

Forest Products is the third-largest manufacturing sector in consumption of fossil fuel energy and is a major user of water.[4]

Although the sector is energy intensive, it has a high level of cogeneration and use of biomass to produce energy.

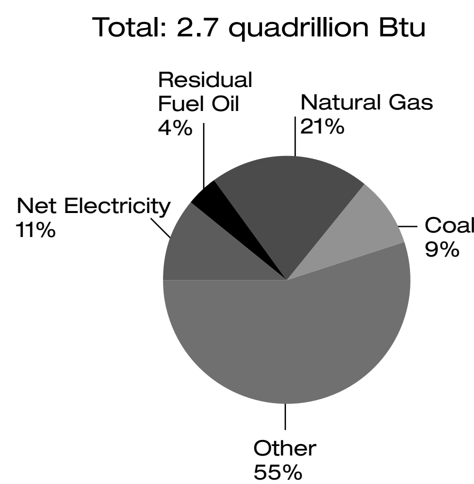
The sector accounts for nearly 6% of the total value of shipments (VOS) in U.S. manufacturing.[5]

Energy Use

Making paper is energy and water intensive. A significant amount of energy is needed, for example, to remove water from the dilute fiber slurry that is the beginning stage of making paper from pulp. The recovery furnaces that regenerate the chemicals that cook wood chips to produce pulp also require large quantities of energy. The pulp and paper portion of the sector is especially energy intensive. In

FIGURE 1

Fuel Use for Energy 2002



Notes:
1. Other is primarily generation from renewables and net steam (the sum of purchases, generation from renewables, and net transfers).
2. Net electricity is an estimation of purchased power and power generation onsite.

Source: U.S. Department of Energy

2002 the manufacture of wood products counted for 375 trillion Btu, or about 14% of the sector's energy use; 2,361 trillion Btu, or 86%, was attributable to pulp and paper mills.[6]

Renewable fuels account for the majority of energy use at Forest Products facilities, which represent 93% of all U.S. manufacturing in use of wood byproduct fuels, such as bark, wood waste, and spent pulping liquor.[7] Bark and wood waste are burned in power boilers to produce electricity and steam for a facility. Pulp manufacturing facilities burn spent pulping liquor, a solution of wood lignin (an organic polymer) from process chemicals, in recovery boilers to produce steam and regenerate the process chemicals. Figure 1 shows fuel used for energy in 2002 in the sector.

The American Forest & Paper Association (AF&PA) and U.S. Department of Energy (DOE) formed the Agenda 2020 Technology Alliance in 1994 to cut energy use and emissions through innovations in technology, manufacturing processes, and market development. The Alliance, now independent of DOE, partners with governments and local and international organizations; shares information on new advances such as biorefineries that produce fuels from wood; and partners on efforts including research and development into renewable, bio-based products such as fibers, fuels, and chemicals.[8]

Many facilities have achieved long-term reductions in energy intensity through process efficiencies and cogeneration.[9] Cogeneration, or combined heat and power (CHP), increases energy efficiency through onsite production of thermal energy and electricity from a single fuel source. Pulp and paper facilities are leaders in using cogenerated energy. About 89% of the electricity generated at paper mills was cogenerated in 2002. Typically, 99% of the electricity generated at wood products facilities is cogenerated.[10] The sector overall produced 37% of all cogenerated energy in manufacturing in 2002, second only to the Chemical Manufacturing sector. Forest Products facilities have opportunities for short-term fuel switching, although fuels with fewer emissions or greater efficiency can be more costly.[11]

Air Emissions

Air emissions from the sector include criteria air pollutants (CAPs), greenhouse gases (GHGs), and a number of chemicals reported to EPA's Toxics Release Inventory (TRI). Fuel combustion and manufacturing contribute to air emissions from this sector. In general, the "toxic chemicals" tracked by TRI are found in the raw materials and fuels used in the manufacturing process, and can be generated in byproducts or end products. Toxic chemicals from this sector may be generated and emitted to the environment during wood processing, chemical recovery, and papermaking operations in pulp and paper mills and during drying and pressing operations in wood products plants. CAPs and GHGs also are generated as combustion byproducts from onsite energy production and from some production processes and other activities.

Air Emissions Reported to TRI

In 2005, 1,144 facilities in the sector reported to TRI 206 million absolute lbs. of air emissions. Between 1996 and 2005, absolute TRI-reported air emissions declined by 24%, as shown in Figure 2a. When normalized by the sector's VOS over the period, air emissions decreased 12%, as seen in Figure 2b.[12] While these 1,144 facilities only accounted for about 5% of Forest Products facilities, this number includes virtually all pulp and paper mills, as well as the larger and more chemically intensive wood products manufacturing facilities.

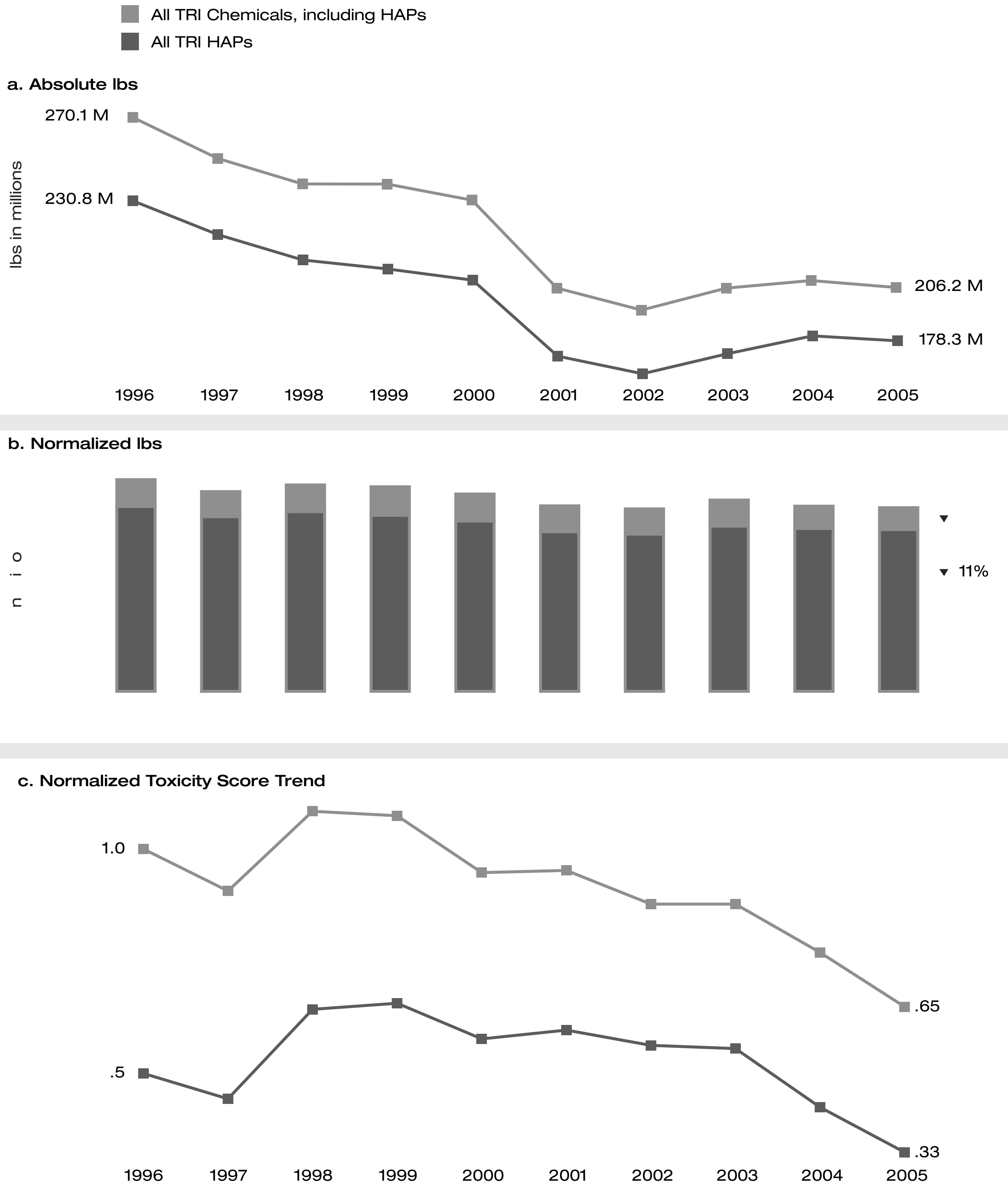
To consider toxicity of air emissions, EPA's Risk-Screening Environmental Indicators (RSEI) model assigns every TRI chemical a relative toxicity weight, then multiplies the pounds of media-specific releases (e.g., pounds of mercury released to air) by a chemical-specific toxicity weight to calculate a relative Toxicity Score. RSEI methodological considerations are discussed in greater detail in the Data Guide, which explains the underlying assumptions and important limitations of RSEI.

Data are not reported to TRI in sufficient detail to distinguish which forms of certain chemicals within a chemical category are being emitted. For chemical categories such as chromium, the toxicity model conservatively assumes that chemicals are emitted in the form with the highest toxicity weight (e.g., hexavalent chromium); thus, Toxicity Scores are overestimated for some chemical categories. Summing the Toxicity Scores for all of the air emissions reported to TRI by the sector produces the trend illustrated in Figure 2c.

The TRI list of toxic chemicals includes all but six of the hazardous air pollutants (HAPs) regulated under the Clean Air Act. Regulations regarding combustion byproducts, issued in 1997, required pulp and paper mills to add

FIGURE 2

Air Emissions Reported to TRI 1996–2005



Note:
Normalized by annual value of shipments.

Sources: U.S. Environmental Protection Agency, U.S. Department of Commerce emission controls to the pulping, pulp washing, and pulp bleaching processes. Eighty-six percent of pulp and paper TRI air emissions are also HAPs, so air emission trend lines for all TRI chemicals and for HAPs declined similarly over the past decade.[13]

Absolute TRI air emissions decreased 24% since 1996. When normalized by VOS, absolute emissions fell 12%.[14] Toxicity Scores, when normalized by VOS, decreased 35% over this period, indicating that the falling Toxicity Scores reflect an environmental performance improvement, rather than simply a decline in production levels.[15]

Table 1 presents the top TRI-reported chemicals emitted to air by the sector based on three indicators. Each indicator provides data that environmental managers, trade associations, or government agencies might use in considering sector-based environmental management strategies.

1) Absolute Pounds Reported. Methanol (formed in the pulping of wood chips) and ammonia (formed in the chemical recovery process) were the top-ranking chemicals based on pounds emitted to air in 2005.

TABLE 1

Top TRI Air Emissions 2005

Chemical	Absolute Pounds Reported[1]	Percentage of Toxicity Score	Number of Facilities Reporting[2]
Acetaldehyde[3]	8,518,000[4]	4%	156
Acrolein	53,000	11%	6
Ammonia	16,769,000	1%	170
Chlorine Dioxide	546,000	11%	78
Dioxin and Dioxin-Like Compounds	<1	<1%	272
Formaldehyde	6,390,000	9%	217
Hydrochloric Acid	15,979,000	3%	136
Lead	43,000	1%	535
Manganese	184,000	15%	148
Methanol	126,057,000	<1%	362
Polycyclic Aromatic Compounds	96,000	3%	205
Sulfuric Acid	7,886,000	32%	99
Toluene	10,120,000	<1%	175
Percentage of Sector Total	93%[5]	90%[6]	76%[7]

Notes:
1. Total sector air releases: 206 million lbs.
2. 1,144 total TRI reporters in the sector.
3. *Italics* indicate a hazardous air pollutant under section 112 of Clean Air Act.
4. Red indicates that the chemical is one of the top five chemicals reported in the given category.
5. Chemicals in this list represent 93% of the sector's air emissions.
6. Chemicals in this list represent 90% of the sector's Toxicity Score.
7. 76% of facilities reported emitting one or more chemicals in this list.

Source: U.S. Environmental Protection Agency

2) Percentage of Toxicity Score. Top-ranked chemicals based on Toxicity Scores include sulfuric acid from coal and oil burning in boilers, manganese from burning wood and coal, and chlorine dioxide from pulp bleaching. Together these chemicals accounted for more than half of the sector's overall Toxicity Score in 2005.

3) Number of Facilities Reporting. Lead from fossil fuel boilers, and methanol, were the most frequently reported chemicals. Two-thirds of facilities reporting TRI air emissions reported emissions of at least one of these two chemicals.

When wood and coal are burned, manganese is either emitted or partitioned to ash and subsequently landfilled. In 1997, EPA clarified TRI reporting requirements regarding combustion byproducts. Subsequently, metal byproducts from combustion of coal and oil are considered "manufactured" and therefore included in the reporting threshold calculation. This clarification resulted in new manganese reporting for many facilities and, thus, an increase in the amount reported to TRI.[16]

Criteria Air Pollutants

Table 2 shows CAP and volatile organic compound (VOC) emissions from facilities in the Forest Products sector for 2002.

TABLE 2

Criteria Air Pollutant and VOC Emissions 2002

	Tons
SO_2	366,000
NO_X	277,000
PM_{10}	118,000
$PM_{2.5}$	76,000
CO	460,000
VOCs	245,000

Note:
PM_{10} includes $PM_{2.5}$ emissions.

Source: U.S. Environmental Protection Agency

The major CAP emissions from Forest Products manufacturing—carbon monoxide (CO), nitrogen oxides (NO_X), and sulfur dioxide (SO_2)—primarily are generated in combustion sources such as power boilers. NO_X and SO_2 can be transported over long distances and contribute to ozone and particulate emissions in urban areas that are downwind of facilities.

More recent data collected by AF&PA indicate a 12% decrease in SO_2 emissions per ton of production from 2002 to 2004, and a 9% decrease of NO_X emissions per ton of production. These reductions were gained through more sophisticated process controls, additional pollution control equipment, and use of low-sulfur fuels.[17]

Greenhouse Gases

The sector's GHG profile is diverse. It includes direct and indirect carbon dioxide (CO_2) emissions from manufacturing operations. Forests also serve as carbon sinks, absorbing CO_2 from the atmosphere through growth. When harvested, carbon in the trees is transferred to forest products, which can lead to long-term storage of the carbon as in structures such as houses or in disposal sites.[18]

AF&PA participates in Climate VISION, a DOE-industry voluntary partnership to reduce GHG intensity, which is the ratio of GHGs to economic output. AF&PA member companies manufacture more than 80% of the paper and approximately half the wood products produced in the United States. Under Climate VISION, AF&PA members have committed to reduce GHG intensity by 12% by 2012 relative to a 2000 baseline.[19]

AF&PA reported that its members' direct GHG emissions from fossil fuel use and process emissions were 51.4 million metric tons of CO_2 equivalent ($MMTCO_2E$) in 2004, down from 61.2 $MMTCO_2E$ in 2000, and that GHG emissions from the generation of electricity purchased were 26.2 $MMTCO_2E$ in 2004, down from 26.8 $MMTCO_2E$ in 2000.[20] Table 3 presents the estimated GHG emissions for the sector; the estimates did not factor in carbon sequestration or GHG emissions from wastewater treatment.[21]

TABLE 3

Estimated GHG Emissions 2004

	Million Metric Tons of Carbon Dioxide Equivalent
Fossil Fuel Combustion and Process Emissions	51.4
Electricity[1]	26.2
Total	**77.6**

Note:
1. Indirect emissions from generation of purchased electricity.

Sources: American Forest & Paper Association, National Council for Air and Stream Improvement

Water Use and Discharges

As noted above, pulp and paper making is water-intensive. In pulp bleaching, for example, bleaching occurs in stages and the pulp must be washed between the stages. Many facilities are recycling water where possible and attempting to reduce the need for water.

Wastewater discharges are a major focus for this sector. In 2005, 370 Forest Products facilities reported water discharges of TRI chemicals totaling 20.5 million lbs., an 18% increase since 1996, when normalized by VOS over this period.[22] The predominant TRI chemicals discharged in 2005 included nitrate compounds, methanol, manganese, and ammonia. Combined, these chemicals accounted for 91% of the total TRI chemicals discharged to water that year. Pulp and paper mills accounted for almost all of the sector's water discharges.[23]

Forest Products manufacturing facilities discharge wastewater either to Publicly Owned Treatment Works (POTWs) or directly into waterways. Every facility discharging process wastewater directly to waterways must apply for a National Pollutant Discharge Elimination System permit. The permits typically set numeric limits on specific pollutants and include monitoring and reporting requirements. For facilities in this sector, regulated pollutants and the associated limits vary depending on the product being manufactured. For example, permits for wood-preserving facilities limit their discharges to POTWs of oil and grease, copper, chromium, and arsenic, and limit their discharges to waterways of oil and grease and phenols. Permits for pulp and paper mills limit zinc, among other pollutants, in their POTW and direct discharges.[24] The state of the best and most current discharge control technology, pollutant control technology, and economic feasibility also help determine the quantity or quality of discharge limits.

Pulp and paper mills also discharge effluent that lowers oxygen levels in receiving waters. In 1995, pulp and paper mills discharged approximately four lbs. of biochemical oxygen demand (BOD) per ton produced. In 2002–2004, the BOD of their effluent was 2.6 and 2.8 lbs. per ton produced, respectively.[25] The long-term trend toward reduced BOD is due to improved production processes and wastewater treatment, in response to state and federal regulations. The sector also has reported a significant long-term decrease in total suspended solids (TSS) in its discharges due to improved wastewater treatment, also in response to regulatory requirements.

Water discharges became a major focus in the 1980s when dioxins were found in waters that received pulp mill effluent. Since then, elemental chlorine bleaching of pulp has been replaced by bleaching processes based on chlorine dioxide, and dioxin pollution has dropped below detectable levels.[26] Current water toxics concerns are discharges of lead and nitrate compounds; lead accounts for the highest toxicity weighting among the water discharges, and nitrates account for more pounds of discharge than other listed toxins. Conventional discharges of concern are TSS and BOD.

In addition to being regulated for direct and POTW discharges, those facilities with materials exposed to precipitation are regulated for stormwater runoff, usually under a general permit that provides sector-specific limits. Stormwater effluent limits are set for TSS, chemical oxygen demand, arsenic, phenols, and metals—zinc, copper, and chromium.[27]

Reducing Water Use

Stora Enso Duluth Paper Mill and Recycled Pulp Mill, in Duluth, MN, reduced water use relative to production by nearly 25% from 2002 to 2006. The facility focused on water reuse and use of previously sewered water. Instead of using fresh water, for example, the facility's retention aid injection system now uses water that had been going to the sewer. With these and other measures, the mill has saved $398,000 over three years.[28]

Waste Generation and Management

Hazardous Waste Management

In 2005, 403 Forest Products facilities reported to EPA's *National Biennial RCRA Hazardous Waste Report* (BR) generating 136,000 tons of hazardous waste. The number of facilities reporting hazardous waste generation and the quantities reported in this sector were evenly distributed between the wood and paper products subsectors. The predominant source of hazardous waste generation in the sector was ongoing production and service-related processes. The predominant types of hazardous waste reported by the sector in 2005 were F034 (defined as wastewaters, process residuals, preservative drippage, and spent formulations from wood-preserving processes generated at plants that use creosote formulations) and corrosive waste, together representing three-quarters of the total generated wastes.[29] The sector reported managing 396,000 tons of hazardous waste. The difference between wastes generated and waste managed was due to groundwater remediation efforts at two wood products facilities.

Waste Management Reported to TRI

In 2005, the Forest Products sector reported managing 1.7 billion absolute lbs. of TRI chemicals in waste. As shown in Figure 3, when normalized by VOS, the quantity of waste managed by the sector remained relatively steady between 1996 and 2005. In 2005, 15% of the TRI-reported waste was disposed or released, 66% was treated, 12% was recovered for energy, and 6% was recycled. Pulp and paper mills accounted for almost all (95%) of the sector's waste managed.[30] There has been little change in the management methods used by this sector over the last decade.

In 2005, the sector reported disposing 29 million lbs. of TRI chemicals to land, or transferring the chemicals offsite for disposal. As shown in Table 4, manganese accounted for almost half of the total pounds disposed by the sector in waste. Zinc and barium were also disposed in large quantities. Lead was the chemical most frequently reported as disposed, followed by dioxin and dioxin-like compounds.

TABLE 4

Top TRI Disposals 2005

Chemical	Absolute Pounds Reported[1]	Number of Facilities Reporting[2]
Barium	3,638,300[3]	98
Dioxin and Dioxin-Like Compounds	2	204
Lead	587,000	423
Manganese	13,623,400	140
Mercury	1,500	113
Methanol	1,010,700	119
Vanadium	1,397,500	39
Zinc	7,458,600	108
Percentage of Sector Total	96%[4]	43%[5]

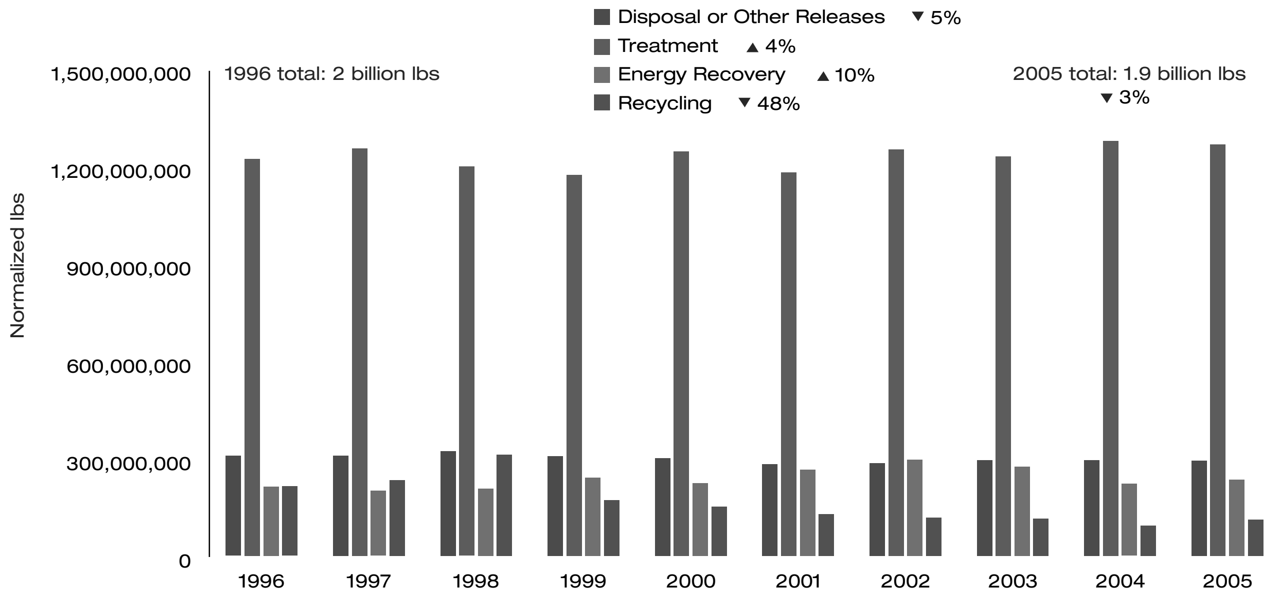
Notes:
1. Total sector disposals: 29 million lbs.
2. 1,144 total TRI reporters in the sector.
3. Red indicates that the chemical is one of the top five chemicals reported in the given category.
4. Chemicals in this list represent 96% of the sector's disposals.
5. 43% of facilities reported disposals of one or more chemicals in this list.

Source: U.S. Environmental Protection Agency

The sector continues to find ways to recycle waste and process byproducts—for energy production, reuse in new products, agricultural applications, and soil enrichment.[31] Kraft pulping mills burn spent pulping mixtures to generate energy and to recover pulping chemicals. Other wastes, such as wastewater treatment residuals and boiler ash, are increasingly being used as soil amendments. From 2002

FIGURE 3

TRI Waste Management 1996–2005



Notes:
1. Normalized by annual value of shipments.
2. Disposal or other releases include air releases, water discharges, and land disposals.

Sources: U.S. Environmental Protection Agency, U.S. Department of Commerce

to 2004, the proportion of wastewater treatment residuals used for land application increased from 12% to 16%.[32]

The sector's involvement in resource recovery goes beyond its own industrial processes. About 52% of the paper consumed by all users in the United States is recovered for recycling; AF&PA has a goal to raise that percentage to 55% by 2012.[33]

Additional Environmental Management Activities

Many of the technology goals and research of the Agenda 2020 Technology Alliance would also improve environmental performance by reducing water use, finding beneficial uses for process wastes, and improving recycling.[34] Breakthrough technologies that would allow for more concentrated slurries at the beginning of the papermaking process, for example, would save both energy and water. Enhancements in chemical recovery that would either improve or eliminate lime kilns could save substantial amounts of fuel.

Forest biorefineries (described in the "Energy Use" section) could turn what are currently low-value byproducts and fuels into higher value chemicals and fuels. Wood contains three main chemical components: cellulose, hemicellulose, and lignin. Current pulping technology extracts the cellulose, which is used to make paper pulp; the lignin, which is burned for fuel; and the hemicellulose, which converts to certain sugars. The biorefinery would add three new processes. First, hemicellulose would be extracted from chips before pulping and would be converted either to ethanol fuel or other industrial chemicals. Second, boilers that currently burn waste biomass (e.g., bark, waste chips) would instead convert the biomass to syngas, an intermediate product that could then either be burned as a fuel or further converted to a mixture of fuels and chemicals similar to crude oil. Third, the spent pulping liquor containing lignin and pulping chemicals could itself be gasified for fuel, while continuing to recover pulping chemicals for reuse.[35]

These new technologies are at various stages of research and development. New mandates and market opportunities for renewable fuels are prompting accelerated efforts to commercialize forest-based biofuels, and production plants may start up in the next few years.