

IV

Air Quality Issues in the Four-state Border 2012 Region

*Gerardo Mejía, Ross Pumfrey, Diana Borja,
Steve Niemeyer, Jorge Sánchez, and Alejandra Estrada*

ABSTRACT

The Four-state Region (FSR), as defined by the binational Border 2012 Environmental Program, includes those portions of the Mexican states of Tamaulipas, Nuevo León, and Coahuila within 100 kilometers (km) of the international border and the counties of Texas that fall within 100 km of the Texas' border with those three states.

No areas in this region have violated any of the national standards for regulated pollutants in either country. Nevertheless, selected air quality concerns exist, most of them related to short-term local episodes but one related to a longer-term problem. These are caused either by meteorological conditions combined with the long-range transport of pollutants from outside the region, or by sporadic local air pollution events.

The population and vehicle fleet (important with respect to generating emissions) in the region are growing at high rates. The population grew 36% from 1990 to 2000 in the Mexican portion of the FSR and 42% in the Texas portion. The combined population in 2000 was 2.74 million and could reach 3.79 million and 5.27 million

Binational Air Quality Management

in 2010 and 2020, respectively. A majority of the population of the FSR resides in the Lower Rio Grande Valley (LRGV), 1.9 million people in 2000, which comprises the counties of Cameron, Hidalgo, and Starr in Texas and the *municipios* of Matamoros, Río Bravo, and Reynosa in Tamaulipas. The population in the LRGV could reach 2.65 million in 2010 and 3.70 million in 2020. Likewise, the number of vehicles was 1.33 million in 2000 in the FSR and could reach 1.84 million in 2010, of which 1.24 million vehicles would be in the LRGV.

Long-distance transport of U.S.-generated ozone and Saharan dust cause occasional, short-term problems related more to health issues in other parts of the FSR. The possible impact of pollution carried from Monterrey is unstudied. Other concerns relate to agricultural burnings and fires at landfills and illegal dumps, and the possibility of industrial contributions to some smoke events. Additionally, the growing population and vehicle use could, over the long term, have an impact on air quality, and more immediately the increase in diesel truck traffic tied to international trade merits tracking. It is important to maintain updated data on emissions, population, and the vehicle fleet and evaluate developments in the area in order to anticipate and prevent air quality problems in the future.

A different kind of air quality concern, but an ongoing one, relates to the degradation of visibility at Big Bend and Maderas del Carmen national parks (“sister” parks abutting the border). U.S. law requires that this be addressed. Analyses demonstrate that this problem is caused by pollution (principally particulate matter) transported by winds into the western part of the region from both countries.

Temas sobre la Calidad del Aire en la Región de los Cuatro Estados de Frontera 2012

*Gerardo Mejía, Ross Pumfrey, Diana Borja,
Steve Niemeyer, Jorge Sánchez y Alejandra Estrada*

RESUMEN

La Región de los Cuatro Estados (por sus siglas en inglés, FSR), de acuerdo con la definición del Programa Ambiental binacional de Frontera 2012, incluye las secciones de los estados mexicanos de Tamaulipas, Nuevo León y Coahuila que se encuentran dentro de 100 kilómetros (km) de la frontera internacional y los condados de Texas que están dentro de 100 km de la frontera de Texas con estos tres estados.

Ninguna de las áreas en esta región ha violado ninguno de los estándares nacionales para contaminantes regulados en ambos países. No obstante, existen ciertas preocupaciones en cuanto a la calidad del aire. La mayoría de éstas se relacionaron con episodios locales de plazo corto, pero uno se relacionó a un problema de un plazo más largo. Estos son causados ya sea por condiciones meteorológicas combinadas con el transporte a gran distancia de contaminantes desde fuera de la región, o bien, por eventos locales esporádicos de contaminación del aire.

La población y la flota vehicular (importantes con respecto a la generación de emisiones) en la región están creciendo a ritmos acelerados. La población creció 36% de 1990 al año 2000 en la parte mexicana de la FSR y 42% en la parte texana. La población combinada en el año 2000 fue de 2.74 millones y podría alcanzar 3.79 y 5.27 millones en los años 2010 y 2020, respectivamente. La región de la parte inferior del Río Bravo (Lower Rio Grande Valley LRGV), donde reside la mayoría de la población de la FSR,

comprende los condados de Cameron, Hidalgo y Starr en Texas y los municipios de Matamoros, Río Bravo y Reynosa en Tamaulipas. La FSR tenía una población de 1.9 millones en el año 2000. La población en el LRGV podría alcanzar 2.65 millones en el año 2010 y 3.7 millones en el año 2020.

De la misma manera, la flota vehicular era de 1.33 millones en el año 2000 en la FSR y podría alcanzar 1.84 millones en el año 2010, de los cuales 1.24 millones de vehículos están dentro de la LRGV. El transporte a gran distancia de ozono generado en los Estados Unidos y polvo del Sahara causan problemas ocasionales de corto plazo relacionados más con cuestiones de la salud en otras partes de la FSR. El posible impacto del transporte de contaminantes desde Monterrey no ha sido estudiado. Otras preocupaciones están relacionadas con las quemadas agrícolas, los incendios en los rellenos sanitarios y los tiraderos ilegales y a la posible contribución de las industrias en episodios de contaminación por humos. Adicionalmente, la creciente población y uso de vehículos podría, en el largo plazo, tener un impacto en la calidad del aire. En un plazo inmediato, merita dársele seguimiento al incremento en el tránsito de camiones diésel vinculado con el comercio internacional. Es importante mantener datos actualizados sobre las emisiones, de población y de la flota vehicular y evaluar lo que acontece en la zona para prevenir problemas de calidad del aire en el futuro.

THE FOUR-STATE REGION

The Four-state region (FSR), as defined by the binational Border 2012 Environmental Program, includes those portions of the Mexican states of Tamaulipas, Nuevo León, and Coahuila within 100 kilometers (km) of the international border and the counties of Texas that fall within 100 km of the border with those four states. Figure A the beginning of this monograph is a map of the entire U.S.-Mexican border region, and the easternmost portion of the border is the FSR.

The FSR stretches along the Rio Grande (Río Bravo in Mexico) for approximately 450 miles, from the area known as Big Bend to the Gulf of Mexico. Cross-border “sister cities” have emerged as a

result of traffic, commercial, and industrial activities. The major sister cities are Del Rio-Ciudad Acuña, Eagle Pass-Piedras Negras, Laredo-Nuevo Laredo, McAllen-Hidalgo-Reynosa, and Brownsville-Matamoros. Diverse ecosystems are found in the region, including part of the Chihuahuah Desert, subtropical brushland, and Gulf Coast wetlands.

The volume of trade crossing the border at Laredo-Nuevo Laredo makes that port of entry the largest inland port in the entire United States. Matamoros, which is the largest Mexican city in this region, is the home of two large industrial parks composed chiefly of maquiladoras. The region has good air quality; no areas on either side of the border are in violation of the respective national air quality standards. In Mexico, however, a large municipio very close to the FSR, Monterrey, does have serious air quality problems. Many of the air issues identified in this chapter pertain to short-term events caused by locally generated extraordinary emissions, with few cases of regional concern. The latter derive principally from pollutants coming from other areas, as discussed later in this chapter.

Population in the Four-state Region

The population of the FSR has increased at a relatively high rate in the last two decades, due at least in part to the maquiladora program that began in Mexico in the mid-1960s. The growth accelerated somewhat in the 1990s when the North American Free Trade Agreement (NAFTA) went into effect. Table 1 shows the population in 1980, 1990, and 2000 in the FSR. The municipios within 100 km of the border in Coahuila, Nuevo León, and Tamaulipas had a population of nearly 2.60 million in 2000 (Municipios de Mexico 2005 and Instituto Nacional de Estadística Geografía e Informática 2005), having experienced a growth rate of approximately 25% from 1980 to 1990 and then 26% from 1990 to 2000.

The population of the Texas counties that fall within the FSR was 1.39 million in 2000. The growth rate had been 26% from 1980 to 1990 and then 35% from 1990 to 2000 (U.S. Bureau of the Census 2001).

Binational Air Quality Management

If the growth rates on each side of the border from 1990 to 2000 continue for the period 2000 to 2010, the population in 2010 will be slightly more than 3.27 million in the Mexican portion of the FSR and nearly 1.88 million in the Texas portion, for a total of nearly 5.14 million people. Maintaining the growth rates until 2020 would result in a total regional population of approximately 6.64 million.

The most populous and fastest growing portion of the FSR in both countries is in the sub-region nearest the Gulf of Mexico, known on the Texas side as the Lower Rio Grande Valley (LRGV). This includes the counties of Cameron and Hidalgo in Texas and the neighboring municipios of Matamoros, Río Bravo, and Reynosa in Tamaulipas. This subregion had a combined population of approximately 1.36 million in 1990 and grew to 1.90 million in 2000, reflecting a combined growth rate of approximately 39% (see Table 2). Part of this subregion, the McAllen-Edinburg-Mission Metropolitan Statistical Area (MSA) in Hidalgo County was the fourth fastest growing MSA in the entire United States during the 1990s. If the growth rate in the subregion during the 1990s is projected for the current decade, the population of the area in 2010 would be almost 2.64 million, representing more than 50% of the population of the entire FSR. Assuming a “business as usual” scenario, this growth would result in significantly increased environmental impacts.

Table 1. Population in the Four-state Region, 1980–2000

| Country | State | Population ¹ | | | Growth Rates | |
|---------------|---------------------------------|-------------------------|-----------|-----------|--------------|-----------|
| | | 1980 | 1990 | 2000 | 1980–1990 | 1990–2000 |
| Mexico | Coahuila | 348,306 | 422,165 | 520,510 | 21% | 23% |
| | Nuevo León | 399,085 | 558,983 | 631,400 | 40% | 13% |
| | Tamaulipas | 897,875 | 1,073,997 | 1,444,961 | 20% | 35% |
| | Mexico Subtotal | 1,645,266 | 2,055,145 | 2,596,871 | 25% | 26% |
| United States | Texas/U.S. Subtotal | 819,732 | 1,029,094 | 1,391,200 | 26% | 35% |
| | Regional Total (both countries) | 2,464,998 | 3,084,239 | 3,988,071 | 25% | 29% |

¹ The population data for each state represent the population for those municipios or counties that fall, all or in part, within 100 kilometers of the international border, which is the official definition of the border region. In Coahuila this includes 18 municipios, in Nuevo León 20 municipios, and in Tamaulipas 12 municipios. In Texas this includes 24 counties.

Sources: Municipio de Mexico, Instituto Nacional de Estadística Geografía e Informática, U.S. Census Bureau, Texas Data Center and Office of the State Demographer

Table 2. Population in the Lower Rio Grande Valley

| Municipio/County | Population | | | Growth Rates | |
|------------------|------------|-----------|-----------|--------------|-----------|
| | 1980 | 1990 | 2000 | 1980–1990 | 1990–2000 |
| Matamoros | 238,840 | 303,293 | 418,141 | 27% | 38% |
| Río Bravo | 83,522 | 94,009 | 104,229 | 13% | 11% |
| Reynosa | 211,412 | 282,667 | 420,463 | 34% | 49% |
| Mexican Subtotal | 533,774 | 679,969 | 942,833 | 27% | 39% |
| Cameron | 209,727 | 260,120 | 335,227 | 24% | 29% |
| Hidalgo | 283,323 | 383,545 | 569,463 | 35% | 48% |
| Starr | 27,266 | 40,518 | 53,597 | 49% | 32% |
| Texas Subtotal | 520,316 | 684,183 | 958,287 | 31% | 40% |
| Total | 1,054,090 | 1,364,152 | 1,901,120 | 29% | 39% |

Sources: The 1980 data for the Mexican municipios come from Municipio de Mexico. The 1990 and 2000 data for the Mexican municipios come from the Instituto Nacional de Estadística Geografía e Informática. Data on Texas counties come from the U.S. Census Bureau, through the Texas Data Center and Office of the State Demographer.

Vehicle Fleets in the Four-state Region

Vehicles are one of the leading sources of emissions, and therefore tracking the growth in their numbers can be informative. Table 3 shows the growth in the number of vehicles in the Mexican portion of the FSR. If these data are compared with the population data in Table 1, it can be seen that the number of vehicles has been growing at a significantly higher rate than the population. In the Mexican states, the fleet grew approximately 88% from 1980 to 1990 and then 41% from 1990 to 2000, compared to 25% and 26% growth rates for the population in those two decades. Vehicle data are not available for the counties in Texas prior to 1996, but Table 4 offers the data for 1996 and 2000. The four-year growth rate in vehicles appears to approximate roughly the population growth.

Table 3. Number of Vehicles in the Mexican Municipios of the Four-state Region, 1980–2000

| State in Mexico | Number of Vehicles | | | Growth Rates | |
|---|--------------------|---------|---------|--------------|-----------|
| | 1980 | 1990 | 2000 | 1980–1990 | 1990–2000 |
| Coahuila | 31,632 | 90,717 | 92,270 | 187% | 17% |
| Nuevo León | 3,337 | 7,660 | 34,763 | 130% | 54% |
| Tamaulipas | 110,161 | 182,623 | 314,452 | 66% | 72% |
| Tamaulipas (other municipios in region) | 54,240 | 94,769 | 179,572 | 75% | 89% |
| Total for Mexican Portion of Region | 199,370 | 375,769 | 528,787 | 88% | 41% |

Source: Instituto Nacional de Estadística Geografía e Informática

Table 4. Number of Vehicles in the Texas Counties of the Four-state Region, 1996–2000

| Portion of Four-State Region | Number of Registered Vehicles | |
|------------------------------|-------------------------------|---------|
| | FY 90196 | FY 2000 |
| Lower Rio Grande Valley | 434,470 | 506,402 |
| Rest of Texas in Region | 268,780 | 300,744 |
| Total | 703,250 | 807,146 |

Source: Texas Department of Transportation, Vehicle Titles and Registration Division

Tables 3 and 4 do not include information on the average age of vehicles. Vehicles in use in Mexico are comparatively old—it has been estimated that more than half are more than 10 years old. There is a large market in Mexico for older used cars from the United States. These vehicles are poorly maintained, and their emissions are considerably higher than emissions from newer and better-maintained vehicles.

Cross-border Truck Traffic

Table 5 shows the number of northbound truck crossings in nine of the 11 Texas ports of entry in the FSR for the period from 1996 to 2004 (data on two additional ports in Harlingen and McAllen were not available for several of those years). Overall, the number of truck crossings at these nine ports increased by approximately 52% from 1996 to 2004. The busiest crossing was Laredo-Nuevo Laredo, with nearly 1.4 million trucks in 2004. The crossings at this port of entry increased by nearly 36% in this period. The second-busiest port of entry in the region, and fastest growing, was Pharr, with 450,000 trucks passing through (the few data available for Harlingen and McAllen show that neither of those ports had numbers near the levels experienced in Laredo, Pharr, and Brownsville). Several other ports of entry saw crossings increase from 50% to 180% in the same period, but four ports—Falcon Heights, Progreso, and Roma—actually experienced decreases because traffic moved to other crossings with better facilities.

Indications are that international trade under NAFTA—and therefore diesel truck traffic—will continue to increase over time (decreases were experienced at a majority of the ports in 2003 and 2004 because of the economic downturn). However, the potential for further harm to air quality is expected to be largely mitigated by new U.S. regulations on diesel engine emissions, which will be being phased in beginning in 2007 (EPA 2005).

Industrial, Commercial, and Agricultural Activities in Subregions

Economic activities vary along the FSR border area. In the western portion of the region—in the border area with Coahuila—the main border crossing (and therefore the principal traffic) is between Piedras Negras and Eagle Pass. Agricultural activities in this sub-region include the production of wheat, corn, forage, and pecans. Livestock activities are also important, including cattle, goat, pig, and lamb breeding. The chief industrial activities are assembly of machinery and electronics, the Carbon I and II coal-fired power

Table 5. Northbound Truck Crossings at Selected Ports of Entry on the Texas Border with Mexico, 1996–2004

| Location of Crossing ¹ | Annual Number of Crossings ² | | | | | | Growth Rate 1996–2004 |
|-----------------------------------|---|-----------|-----------|-----------|-----------|--|-----------------------|
| | 1996 | 1998 | 2000 | 2002 | 2004 | | |
| Brownsville | 207,564 | 275,661 | 214,816 | 200,444 | 186,947 | | -10% |
| Del Rio | 40,720 | 53,623 | 61,228 | 72,039 | 64,061 | | 57% |
| Eagle Pass | 57,569 | 90,822 | 106,892 | 89,856 | 100,100 | | 74% |
| Falcon Heights | 499 | 397 | 452 | 353 | 103 | | -79% |
| Laredo | 1,015,905 | 1,352,198 | 1,449,873 | 1,441,653 | 1,379,760 | | 36% |
| Pharr | 113,194 | 262,693 | 374,150 | 390,282 | 454,351 | | 301% |
| Progreso | 23,521 | 15,499 | 12,001 | 23,886 | 23,064 | | 98% |
| Rio Grande | 14,403 | 17,871 | 24,065 | 26,330 | 40,815 | | 183% |
| Roma | 12,254 | 13,501 | 12,824 | 9,600 | 8,407 | | 69% |
| Total | 1,485,629 | 2,082,265 | 2,256,301 | 2,254,443 | 2,257,608 | | 52% |

¹ Two ports of entry—Harlingen and McAllen—are not included because several years of data are not available. The data that are available indicate that neither of these two ports would be in the top three in terms of volume of traffic.

² These numbers represent 2- to 6-Axle Loaded and Unloaded Commercial Vehicles

Source: Texas A&M International University, Texas Center for Border Economic and Enterprise Development

Binational Air Quality Management

plants near Piedras Negras, and steel companies. Coal and natural gas are being extracted in the area to supply energy for the different activities (Gobierno del Estado de Coahuila de Zaragoza 2005).

The border between Nuevo León and Texas is only about 20 km long, although it includes the Colombia bridge and border crossing, where the traffic is mainly heavy diesel trucks crossing the border in both directions. There are small towns in this sub-region in both Texas and Nuevo León and various forms of agricultural activity. The large metropolitan area and industrial center of Monterrey is outside the 100 km definition of the border region, but still relatively close (within 200 km of the border). Its many sources of emissions may have an impact on air quality in the region, depending on the meteorological conditions on any particular day, including the prevailing winds.

The Tamaulipas-Texas area of the region is home to numerous economic activities. Population on the Mexican side is concentrated mainly in the cities of Nuevo Laredo, Reynosa, Río Bravo, and Matamoros. In Tamaulipas, international border crossings exist with the Texas cities of Laredo, Roma, Rio Grande, Hidalgo, Pharr, Progreso, Harlingen, and Brownsville. In the Laredo-Nuevo Laredo area, traffic from international trade is the leading activity. Commercial activities connected to trade, such as custom brokerage and warehousing, are also important in the area.

The eastern part of that Tamaulipas-Texas border area—Texas's Lower Rio Grand Valley (LRGV) and its sister cities—has agricultural and commercial activities in both countries. The main crops include green peppers, tomatoes, squash, cantaloupe, watermelons, grain sorghum, broom sorghum, peas, green beans, corn, fodder sorghum, okra, broccoli, pinto beans, onions, carrots, and cotton. Cattle breeding is important in the rural areas surrounding the cities (popular breeds include Charolais, Brahman, and Indo-Brazil). Other activities include maquiladoras (more than 250 in Reynosa and Matamoros combined), a refinery in Reynosa, and a power plant in Río Bravo (Gobierno del Estado de Tamaulipas 2005). As noted earlier, this area has more than two-thirds of the population of the FSR and has witnessed increased crossborder traffic (both heavy trucks and light vehicles).

MONITORING AND THE GENERAL STATUS OF URBAN AIR QUALITY IN THE REGION

This section first will summarize the monitoring implemented in the urban areas of the region, with sub-sections treating each side of the border and the generally satisfactory condition of the air quality in those areas. One occasional problem is discussed, related to long-distance transport of ozone into the region. In the following section, several issues of concern will be raised, some of them involving very localized events that pose occasional but very short-term problems and others involving extra-regional phenomena that also affect the area from time to time. Later in the chapter a section will address a different category of air quality concern related to the national parks that are at the northwest end of this region.

Urban Areas on the Texas Side of the Border

The Texas Commission on Environmental Quality (TCEQ) is responsible for monitoring ambient air quality and enforcing the National Ambient Air Quality Standards (NAAQS), which apply to ozone, nitrogen oxides (NO_x), carbon monoxide, sulfur dioxide (SO_2), particulate matter (PM), and lead. The NAAQS and the criteria used to determine attainment of the standards are shown in Tables A and B at the beginning of this monograph. At some sites, TCEQ also monitors volatile organic compounds (VOCs), which are a precursor to ozone and can be a toxic pollutant independent of their relationship to ozone.

In the FSR, TCEQ has air quality monitors in the urban areas where problems could potentially develop—three sites in Laredo and one site each in Brownsville, Mission, Edinburg, Brownsville, and South Padre in the LRGV. Different combinations of pollutants are measured by instruments at each site, as is shown in Table 6. SO_2 and NO_x are not considered potential problems in this region and are not monitored.

Table 6. Urban Monitoring Sites in the Texas Portion of the Four-state Region

| County | Name of Site | Pollutants Measured ¹ |
|---------|--------------------|---|
| Webb | Laredo/Border | Ozone, carbon monoxide, PM ₁₀ , PM _{2.5} , lead, and VOCs |
| | Laredo Bridge | Carbon monoxide, PM ₁₀ , and VOCs |
| | World Trade Bridge | PM _{2.5} |
| Hidalgo | Mission | Ozone, PM ₁₀ , PM _{2.5} , and VOCs |
| | Edinburg | Ozone, PM _{2.5} , and VOCs |
| Cameron | Brownsville | Ozone, carbon monoxide, PM ₁₀ , PM _{2.5} , and VOCs |
| | South Padre | Ozone |

¹ With respect to PM₁₀, PM_{2.5}, and VOCs, there are both “sampler” monitors that measure samples every few days and “continuous” monitors that measure concentrations all the time. Different sites have different configurations of these monitors types.

Source: Texas Commission on Environmental Quality

Measured concentrations of the regulated pollutants in this region have not violated any of the standards. The principle reason for this positive condition is that the prevailing winds, generally from the Gulf of Mexico, disperse the various emissions that are generated locally and do not allow them to stagnate in the urban areas.

On two occasions in the LRGV in the first half of this decade (in September 2001 in Mission and in September 2004 in Brownsville), instruments measured eight-hour ozone averages of 85 parts per billion (ppb) and 86 ppb, respectively. As can be seen in Table B at the beginning of this monograph, a violation of the U.S. standard occurs when the three-year average of the fourth highest value for each year exceeds 85 ppb. Neither of the sites in Mission or Brownsville has exceeded even 75 ppb for any three-year average, but those two episodes prompted analyses by TCEQ.

The explanation of those events raises the issue of long-distance transport of ozone. TCEQ estimates that ozone precursors generated locally in the LRGV are capable of creating concentrations of ozone

not much greater than 20 ppb. Additionally, normal winds and the time it takes for the precursors to interact chemically to produce ozone then cause those locally generated peaks to actually occur 20 miles to 40 miles downwind. At the same time, with prevailing winds from the southeast, ozone levels being transported into the area are typically no higher than about 10 ppb to 30 ppb. Thus, worst-case impacts with southeast winds should be no more than approximately 30 ppb to 50 ppb in areas 20 miles to 40 miles to the northwest of the main urban populations.

Several times a year, however, winds come from the northeast, which can bring pollution from the Houston-Galveston and Beaumont-Port Arthur areas of Texas, as well as from Baton Rouge, Louisiana, and much of the Midwestern United States. TCEQ analysts believe these imported levels of ozone can reach as high as 70 ppb to 80 ppb. On the rare days when wind speeds suddenly decrease significantly in the LRGV, allowing local and imported ozone to combine and stagnate, concentrations over 85 ppb can occur. It is possible that local Mexican sources, such as the Petroléos Mexicanos (Pemex) refinery in Reynosa, could also contribute to elevated ozone readings.

Monitoring on the Mexican Side

So far, monitoring on the Mexican side of the border in this region has been limited to PM₁₀ (particulate matter with a diameter of 10 microns or less). In Tamaulipas, there are four monitoring stations in Matamoros, four in Reynosa, and four in Nuevo Laredo. This monitoring network started in the mid-1990s, but monitoring was not conducted on a regular basis until 2002 in Nuevo Laredo and more recently in Matamoros and Reynosa. The stations take 24-hour samples every six days.

Results of the sampling in this sub-region have not indicated problems during the periods monitored, except for a one-time high reading that occurred at a monitor at the Reynosa-Hidalgo border crossing.

Sources of pollution identified in or near these urban areas include urban dust, vehicle emissions, burning of waste, and biomass (including agricultural) burning. A photochemical model was

used to study the dynamics of pollutants. The model predicted that ozone formation (a result of the interaction of NO_x and VOCs under the influence of sunlight) would usually peak west of the McAllen-Hidalgo-Reynosa border region due to the prevailing winds from the Gulf of Mexico (Mejía, et al. 2003).

Although the sub-region has experienced only isolated problems, the fast-growing population and the increase in the vehicle fleet and crossborder commercial traffic could have a long-term effect on air quality in the LRGV, especially when combined with long-distance transport of pollution into the area.

In the Coahuila portion of the region to the northwest, PM_{10} was monitored at four sites in Acuña and four sites in Piedras Negras for one month in 2003 and in 2004. A mobile unit monitored one site at a time. The data collected did not show any violations of the Mexican standard.

AIR QUALITY CONCERNS

Although there have not been any violations of national ambient standards in the FSR, local citizens have several concerns. These concerns are in three general categories: air quality-related events that occur irregularly and are the result of locally generated problems; seasonal events that result from the long-distance transport of PM; and the unknown potential for long-term impact from the nearby urban metropolis of Monterrey. This section briefly reviews various phenomena that fall into those categories.

Irregular Local Smoke Events

Smoke events caused by landfill fires or other burning occur each year in the LRGV. In the winter of 2004–2005, for instance, the region experienced four such events:

1. For more than a week, beginning on December 19, 2004, a fire at a landfill in Matamoros flared, was partially halted, and flared again, causing respiratory problems not only in that city but also across the border in Brownsville. Hourly

average concentrations of PM₁₀ in Brownsville peaked at 9 a.m. on December 20 at 159 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

2. A landfill fire in Harlingen lasted for a week, from December 23 through December 29. There is no PM₁₀ monitor in Harlingen, so local concentrations were unknown. Smoke from this fire may have had a marginal effect on concentrations in Brownsville, overlapping with the Matamoros fire.
3. For a couple days in late January, another landfill fire in Matamoros caused similar problems, with PM₁₀ hourly averages peaking in Brownsville at 1 p.m. on January 26 at 222 $\mu\text{g}/\text{m}^3$.
4. In early March 2005, smoke coming from Reynosa for a few hours was ascribed to two sources—a fire at an illegal dump and the burning of wastes at a Pemex plant. The hourly average PM₁₀ concentration at 8 a.m. on March 10 was 293 $\mu\text{g}/\text{m}^3$ at the monitor in Mission.

Burning of Field Trash at Sugarcane Plantations

Sugarcane is one of the principal agricultural crops grown on the U.S. side of the border in the LRGV. Organic residue in the fields (referred to as field trash) requires disposal both pre- and post-harvest. The current practice is to burn the field trash. TCEQ has outdoor burning rules, which include guidance that burns should take place only when wind conditions will move the smoke and ash away from populated areas. If property owners in Texas complain about fly ash landing on their property when a burn occurs, the sugar mill owner is obligated to respond and clean up the ash. Despite these rules, TCEQ receives occasional inquiries and complaints from both sides of the border.

On the Mexican side, agricultural burnings also are common. Although there is an Official Mexican Regulation (NOM-015-SEMARNAT/SAGAR 1997) for the burning of agricultural fields, it is usually not followed by local farmers. In Mexico, the sugar growers are typically low-income and for this reason the government is hesitant to impose fines. A social problem thus becomes an environmental problem. The burnings occur without supervision by the

authorities, and the possible environmental and health consequences of this problem have not been evaluated. However, efforts are underway to assess the possible impacts of these burnings on air quality and human exposure.

Exposure to Emissions from Traffic at Border Crossings

The potential problem of emissions from the numerous vehicles (especially diesel trucks) at border crossings is exacerbated by the fact that long lines frequently result in vehicles idling for extended periods. This has caused concern about the possible exposure of people working at the crossings, such as immigration and customs officers, to various types of particulates and VOCs. Peaks of PM₁₀ have been measured by Mexican monitors at border crossings.

A one-time exceedance of the U.S. carbon monoxide standard was measured at the Laredo Bridge by a TCEQ monitor in December 1998, but this appears to have been the result of a meteorological anomaly. Similar concentrations have not been repeated, and the completion of an additional bridge in Laredo the following year reduced whatever localized potential for a problem might have existed.

Agricultural Activities

Agricultural activities are important in the economy of the FSR, in particular in the LRGV. With all the different chemicals involved in these activities, there is concern about the use of pesticides. Studies have been conducted to evaluate potential links between residents' health and environmental pollution (Akland, et al. 1997; Mukerjee, et al. 1997). The results of these studies provide preliminary data on levels, sources, and pathways of exposure and levels of pesticides and polycyclic aromatic hydrocarbons (PAHs). The studies have not yet found any high level of exposure to pesticides on the region.

Transport of Pollutants from Elsewhere in Texas or Northeast Mexico

As described earlier, ozone sometimes travels south from the Houston area to the Lower Rio Grande Valley and can, under meteorological conditions that are relatively rare, create unhealthy air quality conditions.

Another source of middle-distance transport is the Monterrey Metropolitan Area (MMA), which is approximately 120 km from the border and therefore can have a significant impact on the region when the winds are blowing toward the north. Air quality in Monterrey is among the worst in Mexico. Since 1993 the MMA has had five monitoring stations that continuously measure concentrations of PM₁₀, SO₂, NO_x, carbon monoxide, and ozone. In 2003 a monitor for PM_{2.5} (particulate matter with a diameter of 2.5 microns or less) was added. The data have shown numerous violations of two Mexican air quality standards in Monterrey. The one-hour ozone standard has been violated from 10 days to 30 days each year. The 24-hour PM₁₀ standard has been violated from 30 days to 90 days each year. Additionally, since 1993 the standard for annual average concentration of PM₁₀ has been exceeded each year in the MMA. Since 1999, the concentration of PM₁₀ has been increasing, and in some zones of the MMA the annual average has reached values more than twice the standard, posing significant health risks to the local population. Studies and initiatives are underway to better characterize the problem and reduce emissions from various sources.

Transport from More Distant Sources— Smoke and Dust

An example of pollution carried into the region from more distant sources is the smoke that comes from agricultural burning and forest fires in southeastern Mexico and Central America. This typically occurs in an April-through-May timeframe, and can come sporadically during those periods. Because of the pathway and intensity of the smoke, it is experienced across a broad geographic area that extends from the fires themselves to areas several hundred miles north of the FSR.

Binational Air Quality Management

The worst such episode in the FSR in the past decade occurred in 1998, when one-hour averages of $PM_{2.5}$ (PM with an aerodynamic diameter of 2.5 microns or less) were above $100 \mu\text{g}/\text{m}^3$ at the monitor in Brownsville on several occasions during that burning season. Peak hourly averages in similar events in 2000 and 2003 reached levels of $66.2 \mu\text{g}/\text{m}^3$ and $64.6 \mu\text{g}/\text{m}^3$, respectively (TCEQ 2006). Such averages create very short-term unhealthy and upsetting conditions, but fortunately they seldom result in 24-hour averages in this region that exceed the federal standard and that would be viewed as serious public health concerns. Higher averages are experienced, of course, in Mexico to the south of the FSR.

The FSR encounters an additional seasonal air quality problem, but one not caused by any events in the hemisphere. In several episodes between early June and early August each year, sand whipped into the atmosphere by winds over the Saharan Desert and the sub-Sahara in northwest Africa passes over a lengthy swath of coast, extending from Port Arthur, Texas, to Veracruz, Mexico, (and much of the Yucatán Peninsula) after a one- to two-week journey across the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.

Although the north-south extent of this phenomenon is relatively large, and measurable amounts of the dust are carried several hundred miles inland, the peak measurements of PM are usually identified in the U.S.-Mexican border region near the Gulf coast. The stronger episodes reach the level of “moderate” on the U.S. Environmental Protection Agency’s (EPA) Air Quality Index (AQI) scale. The only more serious event since continuous monitoring of $PM_{2.5}$ began in 1999 was an episode that lasted from June 17 through June 20 in 2004 and registered at the level of “unhealthy for sensitive groups.” Daily average concentrations peaked at $46.6 \mu\text{g}/\text{m}^3$ on June 18 in Brownsville (TCEQ 2006).

VISIBILITY AT BIG BEND NATIONAL PARK

In addition to the regulations explicitly related to the criteria pollutants discussed thus far in this chapter, the U.S. Clean Air Act includes special protection for national parks with respect to another ambient air problem—visibility. In the FSR, concern exists about degraded visibility at Big Bend National Park in far West

Texas. A similar problem likely exists across the border from Big Bend in Mexico's Maderas del Carmen National Park, but Mexican law does not include visibility protections and the phenomenon is not tracked there.

In the mid-1990s, EPA and the U.S. National Park Service began working with TCEQ on designing and implementing a study of the haze in Big Bend. Researchers released tracers at selected sites both in eastern Texas and on the U.S. side of the border with Mexico and engaged in intensive monitoring in 1999. Then four years was spent in performing analysis and modeling in an attempt to identify sources of the problem.

The final report, which was issued in September 2004, confirmed what was known generally about haze—that the main cause was fine particulate matter and, in the case of Big Bend, chiefly sulfates formed from SO_2 , which was determined to be 55% of the cause. On the days of least visibility, the study concluded, “sulfates from states to the east and north of Texas were responsible for approximately 22% of the man-made haze at the park.” On those days, approximately 16% of the haze originated in Mexico (presumably at two coal-fired electricity plants in Coahuila) and 11% originated within Texas (U.S. National Park Service 2004).

In 1999 EPA issued “Regional Haze Regulations” to underscore the importance of long-distance transport of the pollutants that reduce visibility (EPA 1999). The regulations encouraged, and provided a small amount of funding for, multi-state cooperation. Texas is working with several other U.S. states on developing a regional strategy. Additionally, because the data were collected at Big Bend in 1999, a new Texas law has required “grandfathered” coal-fired power plants to reduce their emissions of SO_2 . In March 2005 EPA announced the Clean Air Interstate Rule (CAIR), which builds upon a previous a cap-and-trade regime for emissions of SO_2 and NO_x in eastern U.S. states (all the states to the northeast of Texas) (EPA 2005a). Taking a state-by-state approach that will lower each state's allowable emissions, CAIR is expected to result in a 60% reduction in overall SO_2 by 2020 (compared to 2003) and another 7% in subsequent years. Taken together, these Texas and federal actions should have a measurable effect on haze in Big Bend.

LOCAL AIR POLLUTION INITIATIVES

The Border 2012 U.S.-Mexico Environmental Program

The mission of the binational Border 2012 Program is to protect the environment and public health of the U.S.-Mexican border region, consistent with the principles of sustainable development. The program is an agreement among EPA, the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), the eleven border states (six Mexican and four U.S.), and the U.S. border tribes. The program covers goals for air, land, water, health, exposure, and environmental performance. In the case of air, the goal is to reduce pollution with the following objective and interim objectives:

Objective: By 2012 or sooner, reduce air emissions as much as possible toward attainment of respective national ambient air quality standards, and reduce exposure in the border region, as supported by the following interim objectives:

Interim Objective 1. By 2003, define baseline and alternative scenarios for emissions reductions along the border, and their impacts on air quality and human exposure.

Interim Objective 2. By 2004, based on the results of Interim Objective 1, define specific emission reduction strategies, and air quality and exposure objectives to be achieved by 2012.

Within the FSR, as defined by the 100 km zone on each side of the border, the standards for regulated pollutants are being met in both countries, which satisfies the principal Border 2012 objective. But because of the potential impact of growth in the region interacting with imported pollution, a series of workshops and public consultations led to the identification of the following priorities related to air pollution in the FSR:

- Improved collection and cross-border sharing of air emissions inventories
- Expanded collection of emission-related data, to include toxics, particularly from refineries in Monterrey and Reynosa

- Determination of the air pollutants posing the greatest risks in specific geographic regions, and the environmental projects that will yield the greatest benefits for reducing health risks
- Development of smoke-reduction strategies and reduction of particulate emissions, such as from agricultural burning, trash burning, road dust, tire pile fires, and similar sources
- Coordinated reduction of emissions from diesel engines and other high-emitting vehicles

Emission Inventories

Emission inventories provide estimates of the total volumes of pollutant emissions in a geographic area, and also provide disaggregated data on distinct categories of sources. They are powerful tools for evaluating the status and trends of estimated emissions in urban areas or regions of interest. This information is used to develop and evaluate air pollution control strategies. Although air quality has been good in the FSR—with the exception of occasional local episodes—it is still important to develop emission inventories for the region. Tables 7 and 8 present recent aggregated emission inventories for the Mexican *municipios* on the border in the FSR and for the Texas counties in the LRGV, respectively.

Table 7 shows that the regulated pollutants emitted in the largest volumes on the Mexican side are NO_x and SO₂ (ambient concentrations of VOCs and ammonia are not regulated). The *municipio* of Nava, Coahuila, contributes the largest proportion of those pollutants in the FSR, due to the presence of the Carbon I and II coal-fired power plants. The three Tamaulipas *municipios* located in the LRGV (Reynosa, Rio Bravo, and Matamoros) have the next highest contribution, followed by the *municipio* of Nuevo Laredo. Río Bravo shows high NO_x and SO₂ emissions due to the presence of a power plant. It is important to note that the emissions shown in Table 7 were calculated under certain assumptions that need to be re-evaluated to obtain better estimates.

Table 8 shows the emissions in the Texas counties in the LRGV. Reflecting their relative populations, Hidalgo County contributes the largest volume of emissions, followed by Cameron and Starr. Willacy produces the smallest contribution.

Table 7. Emission Inventory for the Mexican Municipios Bordering Texas in the Four-state Region, 1999

| Mexican State | Emissions (in million grams per year) | | | | | | | | | |
|---------------|---------------------------------------|-----------------|-----------------|--------|------------------|-------------------|--------|---------|--|--|
| | Municipio | NO _x | SO _x | CO | PM ₁₀ | PM _{2.5} | VOCs | Ammonia | | |
| Coahuila | Acuña | 5,258 | 814 | 5,948 | 5,445 | 1,019 | 28,532 | 1,248 | | |
| | Guerrero | 1,595 | 21 | 167 | 138 | 46 | 4,219 | 783 | | |
| | Hidalgo | 1,024 | 20 | 141 | 273 | 75 | 3,141 | 385 | | |
| | Jiménez | 2,988 | 156 | 1,418 | 644 | 231 | 4,226 | 605 | | |
| | Nava | 104,626 | 151,139 | 3,104 | 9,314 | 8,233 | 3,271 | 337 | | |
| | Ocampo | 7,742 | 158 | 1,365 | 796 | 227 | 84,368 | 855 | | |
| | Piedras Negras | 1,625 | 590 | 6,722 | 6,209 | 1,172 | 5,720 | 330 | | |
| | Zaragoza | 3,786 | 30 | 455 | 631 | 119 | 29,872 | 1,416 | | |
| | Anáhuac | 3,216 | 117 | 1,183 | 1,003 | 235 | 8,870 | 1,383 | | |
| | Camargo | 654 | 27 | 582 | 857 | 165 | 1,610 | 278 | | |
| Tamaulipas | G. Diaz Ordaz | 259 | 12 | 415 | 835 | 144 | 858 | 148 | | |
| | Guerrero | 1,351 | 25 | 243 | 250 | 65 | 8,657 | 892 | | |
| | Mier | 414 | 7 | 272 | 327 | 55 | 1,028 | 452 | | |
| | Miguel Alemán | 657 | 31 | 665 | 871 | 156 | 987 | 269 | | |
| Nuevo Laredo | Nuevo Laredo | 5,251 | 467 | 20,468 | 11,459 | 2,495 | 13,747 | 702 | | |
| | Ocampo | 727 | 17 | 1,740 | 881 | 278 | 40,842 | 670 | | |

Table 7. continued

| Mexican State | Emissions (in million grams per year) | | | | | | | | | |
|----------------------------|---------------------------------------|-----------------|-----------------|---------|------------------|-------------------|---------|---------|--|--|
| | Municipio | NO _x | SO _x | CO | PM ₁₀ | PM _{2.5} | VOCs | Ammonia | | |
| Tamaulipas | LRGV ¹ | | | | | | | | | |
| | Matamoros | 6,979 | 1,162 | 26,137 | 15,938 | 3,744 | 12,352 | 1,504 | | |
| | Reynosa | 11,974 | 1,160 | 27,937 | 15,247 | 3,468 | 14,180 | 1,129 | | |
| | Río Bravo | 11,699 | 17,270 | 3,772 | 6,594 | 2,238 | 2,817 | 345 | | |
| | Total LRGV | 30,652 | 19,592 | 57,846 | 37,779 | 9,450 | 29,349 | 2,978 | | |
| Total of Border Municipios | | 171,825 | 173,223 | 102,734 | 77,712 | 24,165 | 269,297 | 13,731 | | |

¹ The eastern portion of the Four-State Region, referred to as the Lower Rio Grande Valley (LRGV) on the Texas side of the border, includes the overwhelming majority of the population in the entire region. On the Mexican side of the border, this sub-region comprises three municipios—Matamoros, Reynosa, and Río Bravo.

Table 8. Emission Inventory for the Texas Counties Bordering Mexico in the Lower Rio Grande Valley, 2002

| County | Emissions (in million grams per year) | | | | | | |
|---------|---------------------------------------|------------------------------|---------|-------------------------------|--------------------------------|--------|----------------------|
| | NO _x | SO ₂ ¹ | CO | PM ₁₀ ¹ | PM _{2.5} ¹ | VOCs | Ammonia ² |
| Cameron | 11,105 | 742 | 83,917 | 35,333 | 6,170 | 23,871 | 153,584 |
| Hidalgo | 38,418 | 1,077 | 134,054 | 61,279 | 10,831 | 37,193 | 410,763 |
| Starr | 13,292 | 113 | 19,715 | 12,141 | 2,110 | 18,031 | 40,153 |
| Willacy | 3,793 | 136 | 11,395 | 8,694 | 1,626 | 8,347 | 44,589 |
| Total | 66,608 | 2,068 | 249,081 | 117,447 | 20,737 | 87,442 | 649,089 |

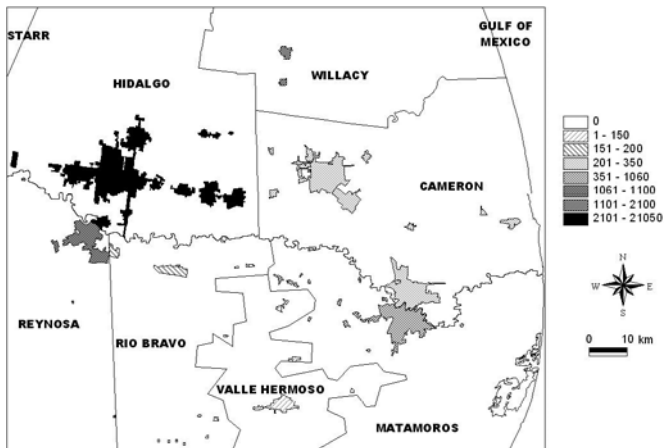
Source: Instituto Tecnológico y de Estudios Superiores de Monterrey and University of Utah

Comparing the data in Table 7 that pertain to the Mexican *municipios* in the LRGV (Matamoros, Río Bravo, and Reynosa) to the Texas LRGV data in Table 8 (ignoring the relatively insignificant three-year difference in the data source for the sake of this analysis) shows that NO_x emissions were 117% higher in the Texas counties than in the Mexican *municipios*. In the case of carbon monoxide, the volume was approximately 330% higher in Texas counties. In the case of SO₂, the emissions in Texas were only about 10% of the emissions in Mexico, while VOCs emissions were 198% higher in Texas. In the case of PM₁₀ and PM_{2.5}, the emissions in the Texas counties of the LRGV were higher than emissions in the Mexican *municipios* by 188% and 119%, respectively. As mentioned, to make a more robust comparison, it will be necessary to obtain better estimates of the emissions inventories for the *municipios*. It will also be important to update the data on both sides of the border over time in order to evaluate the possible implications of various trends.

When disaggregated source data are located geographically and diurnal variability is known, analysts can then use source dispersion models and knowledge of atmospheric chemistry to predict air quality under specified conditions. As an example of such geographical data, Figures 1 through 5 show the geographical distribution of NO_x emissions for area, natural (biogenic), mobile nonroad, mobile on-road, and point sources, respectively. The plots were made using the

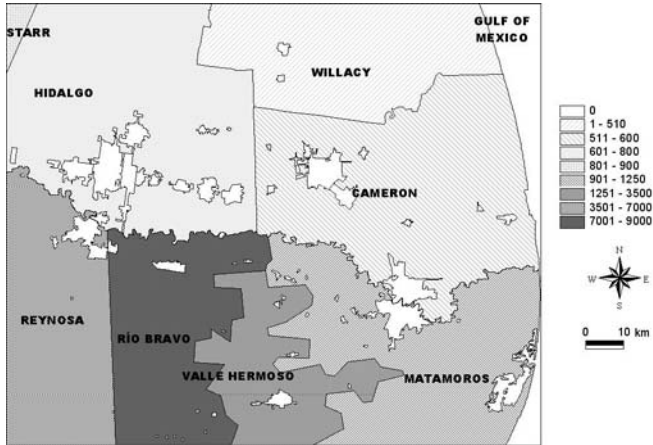
same data on NO_x emissions that were rolled up into the aggregates shown in Tables 7 and 8, and were prepared as part of a project being implemented jointly by the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) and the University of Utah.

Figure 1. NO_x Emissions from Area Sources in the Lower Rio Grande Valley



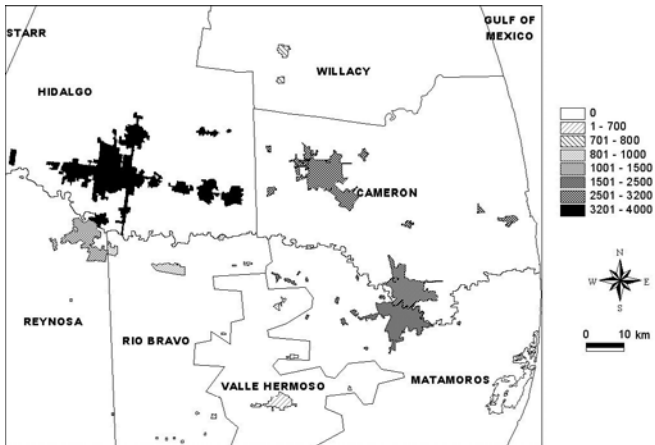
Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 2. NO_x Emissions from Natural/Biogenic Sources in the Lower Rio Grande Valley



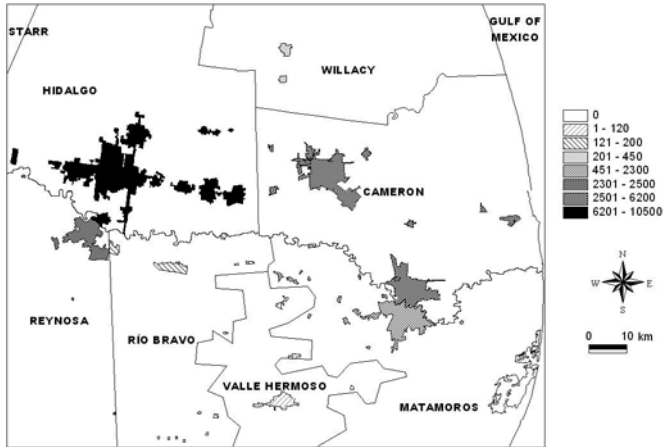
Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 3. NO_x Emissions from Mobile Nonroad Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 4. NO_x Emissions from Mobile On-Road Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 5. NO_x Emissions from Point Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Binational Air Quality Management

In the figures, shading and patterns distinguish different levels of emissions, so urban sources can be easily identified in Figures 1, 3, 4, and 5 (for Figure 2, natural or biogenic sources of NO_x emissions were estimated for the non-urban areas). The U.S. counties have larger NO_x emissions than the Mexican *municipios* in all source categories except the natural/biogenic sources. As mentioned, the Mexican Emission Inventory was estimated with certain assumptions and limitations. If reliable strategies to control air pollution are to be implemented, it is necessary to review those assumptions and obtain an updated emission inventory for the LRGV.

Meteorological, topographical, and land use data are necessary to develop better air quality studies in the region and are available. Data from monitoring sites in the urban areas can be used to validate regional air quality models. On the Mexican side, there is a lack of continuous (rather than sampling) monitoring equipment for PM in the border region itself. Continuous monitoring is performed in Monterrey, and because of that urban center's size and proximity, its emissions may very well play a role in the region's air quality. Analysis by the TCEQ, as described earlier, has already shown that long-distance transport of ozone from Houston and other areas to the northeast is an important factor in the LRGV when winds blow from that direction.

Other Initiatives

In recent years, several initiatives have helped—directly or indirectly—reduce pollution in the FSR, compared with the no-action scenario. Because the FSR is an attainment area, however, resources have not been dedicated to assessing the results of those initiatives.

One type of action that likely has had a beneficial effect has been the modernization of border-crossing facilities and the construction of new such facilities. This has reduced the average waiting time at the border, although in some cases the increase in the number of trucks over time, combined with the security precautions enacted since 2001, may be overwhelming that effect. One example of a net gain occurred with the opening of the World Trade Bridge near in

Laredo, which resulted in lower concentrations of carbon monoxide at the Laredo Bridge (Texas Natural Resource Conservation Commission 2002).

New regulations related to diesel engine emissions and the use of ultra-low-sulfur diesel fuel will begin a phase-in later in 2006 in the United States, and over time this will reduce diesel emissions significantly (EPA 2005b).

In Mexico, technologies in new vehicles have generally improved and are similar to those used in the United States. Also, fuel quality has improved. Leaded gasoline is no longer sold, and low-sulfur diesel fuel is in use, and the Mexican government has declared its intention to introduce ultra-low-sulfur fuel this decade. Also, emission inventories will improve in Mexico as a result of new rules requiring large industries in Mexico to report their emissions in the Annual Operation Report (Cédula de Operación Annual, COA).

Economic incentives are available in both countries to stimulate the introduction of air pollution control and energy-efficiency technologies in industries. There are also initiatives for using alternative fuels, in particular compressed natural gas (CNG), in residential areas and for transportation and industry (the City of Laredo has used U.S. government subsidies to purchase CNG buses). However, the recent high prices of CNG and its availability have at least temporarily slowed new plans for the use of this fuel.

Environmental education has been introduced in official educational programs in Mexico. The government, industry, and service sectors have adopted programs to improve the environment and their own environmental performance. People working in various sectors have the opportunity to attend professional development courses on environmental pollution, its impact on health, and the benefits of pollution prevention.

CONCLUSIONS AND RECOMMENDATIONS

Air quality data from monitoring stations in the FSR indicate that concentrations of measured pollutants in the region are in compliance with standards of both Mexico and the United States. However, there are local, short-term air quality events of an irregular or seasonal nature, mostly in the LRGV, that deserve attention. Also,

some episodes have occurred due to the long-range transport of pollutants that have affected the FSR or emissions of the FSR that have affected other regions.

The population and vehicle fleet in the FSR are growing fast. Depending partly on the development of vehicular technologies, population and economic growth may cause an increase in emissions in the region that, to some degree, compromise air quality. Therefore, it is desirable to maintain current initiatives that reduce emissions and public health risks—in particular the risks to people exposed because of their jobs or other reasons to emissions from heavy traffic, especially diesel trucks. As better fuels become available in the United States and Mexico, the risk of exposure to fuel-related pollutants may not increase.

It is important to maintain and regularly update databases on population, vehicle fleets, truck crossings, and emissions in order to enable periodic assessments of the situation. With this and other related information and evolving analytical techniques, emission inventories can be calculated with the participation of all interested stakeholders. The transboundary pollution, and regional impacts.

ENDNOTE

This chapter includes data from a project being carried out by the University of Utah and the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), with the support of a National Science Foundation-Consejo Nacional de Ciencia y Tecnología (CONACyT) program. The authors gratefully acknowledge their support. Alejandra Estrada also thanks CONACyT and ITESM for financial support during her Master's studies at ITESM.

REFERENCES

- 30 Texas Administrative Codes Chapter 111, Subchapter B.
Akland, G., M. Schwab, H. Zenick, and D. Pahl. 1997. "An interagency partnership applied to the study of environmental health in the Lower Rio Grande Valley." *Environment International Special Issue: Environmental Aspects of the Lower Rio Grande Valley* 23(5).

Air Quality Issues in the Four-state Border 2012 Region

- Gobierno del Estado de Coahuila de Zaragoza. 2005.
<http://www.coahuila.gob.mx/>.
- Gobierno del Estado de Tamaulipas. 2005. <http://www.tamaulipas.gob.mx>.
- Instituto Nacional de Estadística Geografía e Informática. 2005.
<http://www.inegi.gob.mx/inegi/default.asp>.
- Mejía-Velázquez, G., S. Sheya, J. Dworzanski, M. Rodríguez-Gallegos, D. Tejeda-Honstein, J. Cardona-Carrizalez, and H. L. Meuzelaar. 2003. "Characterization and Dynamics of Air Pollutants in the Lower Rio Grande Valley." Pages 121–144 in *The U.S.-Mexican Border Environment: Air Quality Issues along the U.S.-Mexican Border* SCERP Monograph Series No. 6, Alan Sweedler, ed. San Diego: San Diego State University Press.
- Mukerjee, S., W. Ellenson, R. Lewis, R. Stevens, M. Somerville, and S. Shadwick. 1997. "An environmental scoping study in the Lower Rio Grande Valley of Texas – I. Comparative assessment of air sampling methods." *Environment International* Special Issue: *Environmental Aspects of the Lower Rio Grande Valley* 23(5).
- Texas Center for Border Economic and Enterprise Development. 2002-2005. E-mails to co-author Pumfrey and website downloads over a three-year period.
- Texas Commission on Environmental Quality. 2006a.
http://www.tceq.state.tx.us/cgi-bin/compliance/monops/select_summary?region15.gif.
- Texas Commission on Environmental Quality. 2006b.
<http://www.tceq.state.tx.us/compliance/monitoring/air/monops/sigevents06.html>.
- Texas Natural Resource Conservation Commission (now the Texas Commission on Environmental Quality). 2002. "State of the Rio Grande and the Environment of the Border Region." In *Strategic Plan: Fiscal Years 2003-2007* Volume 3. Austin, Texas: Texas Natural Resource Conservation Commission.
- U.S. Bureau of the Census. 2001. Obtained from the website of the Office of the Texas State Demographer in April 2005:
<http://txsdc.utsa.edu/>.

Binational Air Quality Management

- U.S. Environmental Protection Agency. 1999. "Regional Haze Regulations, Final Rule." 40CFR, Part 51.
http://www.epa.gov/ttn/oarpg/t1/fr_notices/rhfedreg.pdf.
- U.S. Environmental Protection Agency. 2005a. "Clean Air Interstate Rule." <http://www.epa.gov/cair/>.
- U.S. Environmental Protection Agency. 2005b. "Diesel Fuel Programs and Regulations."
<http://www.epa.gov/otaq/regs/fuels/diesel/diesel.htm#regs>.
- U.S. National Park Service. 2004. <http://www2.nature.nps.gov/air/Studies/bravo/docs/BravoFactSheet20040915.pdf>.