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Paso del Norte Air Quality

Margarito Quintero Núñez and Craig Forster

Abstract

The Paso del Norte air basin is shared by the communities of El Paso, Tex.; Las Cruces, N.M.; and Ciudad Juárez, Chih. Airborne pollutants emitted from each city mix with emissions from surrounding non-urban land and circulate within a complex transborder air basin. In the United States, El Paso, Tex., is classified by the U.S. Environmental Protection Agency (EPA) as a nonattainment area for particulate matter (PM), carbon monoxide (CO), and ozone (O_3). Pollutant levels in El Paso's twin city, Ciudad Juárez, are no less than those of El Paso (Emerson, et al. 1998; Li, et al. 2001). Nonattainment conditions continue to the present day in Paso del Norte, although air pollutant levels have been declining since the 1980s (Rincón and Emerson 2000). If future population growth is not accompanied by adequate reductions in per capita emissions, pollutant levels could rise. Declining air quality will, in turn, impose constraints on economic development in the border community as air quality mitigation procedures are imposed through regulatory action.

The Border Plus Twenty Years (B+20) Project team used a dynamic simulation model to assess how future air quality conditions might affect economic activity, human health, and quality of life in Paso del Norte. Although it would be desirable to simulate

changes in all pollutants of concern, only variations in PM are considered in this phase of the Paso del Norte modeling activity. This chapter outlines the various factors and issues considered in developing the air quality sector of the Paso del Norte system model. The overall trends in air quality for Paso del Norte are also addressed. The physical and socioeconomic characteristics of the region are described to set the scene for linking air pollution with human health, economy, and quality of life in the model. The few existing studies of air quality effects on human health in Paso del Norte are also summarized. A description of air quality standards, monitoring programs, and approaches to air quality management in the United States, Mexico, and the border region helps outline the regulatory framework for current and future air basin management in the region. The information is incorporated in the air quality sector of the system model, which is being used to explore future air quality scenarios in the Paso del Norte air basin.

La Calidad del Aire en el Paso del Norte

Margarito Quintero Núñez y Craig Forster

Resumen

La cuenca del Paso del Norte es compartida con las comunidades de El Paso, Texas; Las Cruces, Nuevo Mexico; y Ciudad Juárez, Chihuahua. Los contaminantes aerotransportados fueron emitidos de cada mezcla de ciudades vecinas con emisiones de tierras no-urbanas y que circulan dentro de una cuenca transfronteriza compleja. En los Estados Unidos, El Paso es clasificado por la Agencia de Protección Ambiental (EPA) como un área de no logro de materia particulada (PM), monóxido de carbono (CO), y ozono (O_3). Los niveles de contaminantes en Ciudad Juárez, ciudad gemela de El

Paso, son los contaminantes de El Paso (Emerson, et al. 1998; Li, et al. 2001). Las condiciones de no logro hoy en día continúan en el Paso del Norte, aunque los niveles de dichos contaminantes de aire han ido bajando desde 1980 (Rincón y Emerson 2000). Si el futuro crecimiento de la contaminación no es acompañado por reducciones adecuadas de las emisiones per capita, los niveles de contaminantes pudieran subir. La disminución de la calidad del aire puede, a su vez, imponer limitaciones en el desarrollo económico de la comunidad fronteriza mientras que los procedimientos de atenuantes de la calidad del aire son impuestos a través de acciones reglamentarias.

El grupo de trabajo del Proyecto Frontera Más Veinte Años (F+20) utilizó un modelo de simulación de dinámica para evaluar cómo futuras condiciones de la calidad del aire pudieran afectar la actividad económica, salud humana y la calidad de vida en el Paso del Norte.

Aunque lo deseable sería simular cambios en todos los contaminantes de preocupación, sólo variaciones en PM son consideradas en esta fase de la actividad de modelado del Paso del Norte. Este capítulo delimita los diversos factores y temas considerados al desarrollar el sector de la calidad del aire del sistema del Paso del Norte. También son abordadas las tendencias generales en la calidad del aire para el Paso del Norte. Las características físicas y socioeconómicas de la región son descritas para establecer el escenario de unir a la contaminación del aire con la salud humana, economía, y con la calidad de vida en el modelo. También se resumen los pocos estudios existentes de los efectos de la calidad del aire sobre la salud humana. Una descripción de los estándares de la calidad del aire, programas de monitoreo y aproximaciones a la administración de la calidad del aire en los Estados Unidos, México y la región fronteriza ayuda a delimitar el esquema regulatorio para la administración presente y futura de la cuenca de aire en la región. La información está incorporada en el sector de la calidad del aire del sistema de modelo que está siendo usado para explorar futuros escenarios de la calidad del aire en la cuenca de aire en el Paso del Norte.

Physical Characteristics of the Paso del Norte Air Basin

The Paso del Norte air basin is located along the Rio Grande at an elevation of nearly 3,700 feet in basin and range topography typical of the southwest United States and northern Mexico. This natural basin is bounded on the east by the Hueco Mountains of Texas, split on the west by the north-south trending Franklin Mountains of Texas, bounded on the south by the southwest trending Sierra de Juárez Mountains of Chihuahua and defined on the north by topography that rises to the Organ Mountains of New Mexico (Emerson, et al. 1998).

Weather conditions that create unhealthy air quality in the Paso del Norte air basin are typical of those found in high elevation desert basins. In fall and winter, natural temperature inversions develop to trap pollutants in a pool of cold air lying in the bottom of the basin. Because air temperature usually decreases with increasing altitude, a temperature inversion occurs when stable atmospheric conditions cause air temperatures to increase with increasing altitude. In the Paso del Norte air basin, thermal inversions begin in September when the nights grow longer; inversions become increasingly frequent in November, December, and January (TNRCC 1991). During summers, stable atmospheric conditions combined with hot temperatures and abundant sunshine catalyze the photochemical reactions that convert gaseous emissions into ground-level ozone.

Although high winds can clear the air basin of pollutants, low-to-moderate wind speeds lead to mixing within the air basin. El Paso, Tex., and Sunland Park, N.M., are downwind of Ciudad Juárez, Chih., roughly 15% of the time; the reverse is true about 20% of the time. Paso del Norte is located in an arid desert region with annual rainfall varying from five inches to 12 inches (10.8 centimeters [cm] to 30.5 cm). The dry top layers of soil contain fine particles readily entrained by winds that frequently transport airborne dust into the basin from adjacent desert areas.

Socioeconomic Characteristics of the Paso del Norte Air Basin

After the U.S.-Mexican War (1847), in which Texas and New Mexico became part of the United States, the Paso del Norte region became an international border with shared natural resources and the exchange of everything from customs, employment, goods, and services to pollution. El Paso and Ciudad Juárez also became international border cities. This blend of cultures, divided by political and geographic boundaries, has produced an economically viable and dynamic international community. In fact, Paso del Norte is the largest international metroplex in the world (El Paso MPO 1998).

The current population of the combined communities of El Paso, Ciudad Juárez, and Sunland Park exceeds 2 million; about one-third of those residents live in El Paso. It is anticipated that the El Paso population will grow by 18,000 people per year and the Ciudad Juárez population will grow by about 40,000 people per year. The population of Doña Ana County, N.M., is expected to double in the years between 1990 and 2015 (from 135,000 to 332,000), with growth occurring mostly in the southern end of the county as the area around the Santa Teresa Port of Entry is developed. El Paso's population is estimated to increase to 980,000 by 2020 (El Paso MPO 1998).

According to the EL Paso Metropolitan Planning Organization (MPO), approximately 200,000 vehicles are registered in El Paso and 350,000 vehicles are registered in Ciudad Juárez. The older vehicle fleet of Ciudad Juárez means the rate of emissions per vehicle in Ciudad Juárez is greater than that of El Paso (Rincón and Emerson 2000). Meanwhile, active movement of vehicles across the international border (Parks, et al. [2003] estimate about 40,000 vehicles per day) concentrates vehicle emissions at topographically low points in the air basin along the Rio Grande.

The economies of the border communities are intricately interwoven through commercial, industrial, financial, and service activities. Despite this interdependence, there are considerable differences between cities, generated primarily by the unequal distribution of income and the unequal consumption capacity of various social groups in the region. By U.S. standards, El Paso and southern Doña

Ana County are relatively poor, with a per capita income at 59% of U.S. per capita income (El Paso MPO 1998). In Ciudad Juárez, 63% of the population earns less than the Mexican poverty level, which is defined as an income three times the minimum wage (Suarez and Chavez 1996).

A major component of regional trade is found within the maquiladora sector. Maquiladoras are manufacturing facilities set up as "off shore" assembly plants under Mexican law, and under U.S. law they are considered duty-free assembly and cost centers. Companies from the United States, Europe, and Asia operate the facilities directly or in conjunction with Mexican investors to reduce product assembly labor costs. Given specific tariff advantages by the U.S. Department of the Treasury, the maquiladora sector has thrived on inexpensive and plentiful labor from Mexico and easy physical access to the U.S. market. Hundreds of plants that employ thousands of workers in Mexico have accelerated the economic growth of the region as well as its urbanization. This growth and urbanization has led to environmental problems that, like the economic benefits, both communities must share.

The growth of both the maquiladora sector and the population of Ciudad Juárez follow a positive feedback loop. As more companies open facilities in Ciudad Juárez, more workers arrive from other regions in Mexico seeking employment. The population of Ciudad Juárez is estimated to reach 2 million in 2010 (SEMARNAT 1998). In El Paso and Doña Ana Counties, U.S. and multinational corporations are locating production facilities to take advantage of expanding trade under the North American Free Trade Agreement (NAFTA) and convenient access to multi-modal transportation hubs and enterprise zones located in both countries.

The interdependent growth of both population and maquiladoras has occurred at such a rapid rate that growth in border infrastructure has not kept pace with the growth in demand for services. For example, population growth leads to rapid growth in housing needs, which are met by expanding the existing periphery of the Paso del Norte urban area. Roads to the new settlements are frequently unpaved. Roughly 47% of all streets in Ciudad Juárez are unpaved (Velázquez 2002). PM entrained into the air by traffic on unpaved roads creates health, cleanliness, and aesthetic problems for local residents. In El Paso and Doña Ana Counties, low density development associated with suburbanization causes long travel times and travel distances between land uses. The result is an increase in vehicle miles traveled (VMT) and associated difficulties in meeting air quality standards for PM, carbon monoxide, and ozone (El Paso MPO 1998).

Air Quality Issues

Beyond the smoke stacks of the Asarco, Inc. smelters in downtown El Paso and Ciudad Juárez, a monument stands representing Capitan-General Don Juan de Oñate, who led a Spanish colonial expedition across the river in 1598. He named this location "El Paso del Río Norte," which was later shortened to "Paso del Norte." Some 370 years later, in about 1968, the local research community residing in Paso del Norte began to work on air quality issues, stimulated by their observations of poor air quality and the then-recent appearance of the American Association of Science report from its Air Conservation Committee (AAAS 1965).

The National Ambient Air Quality Standards (NAAQS) are promulgated by EPA to measure air quality. NAAQS consists of seven different parameters, six of which are chemical-specific—sulfur dioxide (SO_2), hydrocarbons, ozone, nitrogen oxides (NO_x), carbon monoxide, and lead (Pb); the seventh is a broad measure of the density of suspended particles in the lower atmosphere. This last parameter is the indicator of air quality used in the Border Plus Twenty Years (B+20) model. Particulate matter with a mean aerodynamic diameter of less than 10 microns is referred to as PM_{10}. Because PM_{10} consists of very small particles, it remains suspended in the air for long periods of time and is easily inhaled deep into the lungs. High PM_{10} concentrations have been associated with increased rates of respiratory disease, cardiovascular disease, and mortality.

The most obvious evidence of air quality degradation in Paso del Norte is the frequent, well-defined haze hanging over the region during the morning hours. Parts of El Paso County fail to meet NAAQS for PM_{10}, carbon monoxide, and ozone. Sunland Park exceeds NAAQS for ozone and PM_{10}. Ciudad Juárez air pollution levels exceed the Mexican ambient air quality standards for PM_{10}

(150 micrograms per cubic meter [μg/m^3] for a 24-hour average and 50 μg/m^3 for the annual average), ozone (0.11 parts per million [ppm] for a one-hour average), and carbon monoxide (11 ppm for an eight-hour average). The Mexican long-term, averaged standards are comparable to, or more stringent than, those of the United States.

The principal contributors to PM_{10} emissions in border communities are vehicular emissions, dust from unpaved roads, and atmospheric emissions from industrial processes. These contributing factors are different on opposite sides of the border. For example, the issue of dust particles from unpaved roads is important in Mexico but much less so in the United States. The average mass of PM_{10} emitted per VMT is greater in Mexico than in the United States due to the older cars in Mexico, but the car ownership rates and average VMT per car are greater in the United States. Economic expansion has increased traffic between border cities, which causes longer idling times of vehicles in queue to cross the international border from Mexico into the United States, thus aggravating the region's air quality.

A collaboration of El Paso city and county officials and academics led to a summary publication of much of the 1980s air quality effort in the Paso del Norte region (Gray, et al. 1989). This publication includes a wealth of original data and analysis over several years for carbon monoxide, ozone, and total suspended particulates (TSP). El Paso was out of federal compliance during this time and no data existed for Ciudad Juárez. Carbon monoxide, in particular, had been found to have dramatically high values for hourly maxima—nearly 200 ppm at some times, according to measurements taken at inspection stations. This work ultimately led to the redesign of a clean air supply system for inspection booths on international bridges.

Other issues addressed by Gray, et al. (1989) include the subjects of various symposia, proposals for international accords, and impacts on a new treaty, the La Paz Agreement, which was signed in 1983 by Mexican President Miguel de la Madrid and U.S. President Ronald Reagan. The La Paz Agreement and future annexes, which also have the standing of treaty in U.S. law, specify that EPA and the Mexican Secretaría de Desarrollo Urbano y Ecologia (SEDUE) are the designated federal agencies and that local officials are to be included. This agreement permitted EPA to spend money for air pollution studies or abatement programs that would take place in the border area. At the time, the Mexican government considered the border's air quality to be of lower priority than the markedly more serious air quality problems of Mexico City. In the 1990s, the La Paz Agreement expedited the process for acquiring air pollution data by the various responsible Mexican agencies in the Paso del Norte region. Today, carbon monoxide, ozone, NO_x, and PM_{10} levels are routinely measured on both sides of the border.

Air Quality Standards, Monitoring, and Emissions Inventory

Mexico and the United States have both established health-based air quality standards. When air quality concentrations exceed these proscribed levels, both governments mandate that local agencies use control programs to take action to improve air quality. Table 1 shows U.S. and Mexican air quality standards. In some cases, the standards differ between the two countries. Most notably, the recently adopted eight-hour ozone and $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter) standards do not currently exist in Mexico. Air quality monitoring networks have been deployed throughout the air basin to measure human exposure to these pollutants. There are nine monitoring sites operated by the Texas Commission on Environmental Quality (TCEQ) in El Paso, 11 stations in Doña Ana County operated by the New Mexico Environment Department (NMED), and six monitoring sites in El Paso operated by El Paso City County Health and Environmental District (EPCCHED). The Ciudad Juárez Dirección General de Ecología y Protección Civil (General Directorate of Ecology and Public Safety, in Spanish DGEPC) obtains daily air quality data from equipment at five Ciudad Juárez air quality monitoring sites. EPCCHED provides maintenance, quality control, and technical support for these stations.

Table 1. U.S. and Mexican Air Quality Standards

Pollutant	Mexico		U.S.	
	Units	Average	Units	Average
Ozone	0.11 ppm	1 hour	0.12 ppm	1 hour
Sulfur dioxide	0.13 ppm	24 hours	0.14 ppm	24 hours
	0.03 ppm	Annual arthimetic mean	.03 ppm	Annual arthimetic mean
Nitrogen dioxide	0.21 ppm	1 hour	0.25 ppm	1 hour
			0.053 ppm	Annual arthimetic mean
Carbon monoxide	11 ppm	8 hours	9 ppm	8 hours
			35 ppm	1 hour
Total suspended particles	260 µg/m³	24 hours	n/a	n/a
	75 µg/m³	Annual geometric mean	n/a	n/a
PM_{10}	150 µg/m³	24 hours	150 µg/m³	24 hours
	50 µg/m³	Annual arthimetic mean	50 µg/m³	Annual arthimetic average
Lead	1.5 µg/m³	3 months arthimetic mean	1.5 µg/m³	3 months arthimetic mean

Source: EPA and SEMARNAT 1996

The United States and Mexico have established air quality monitoring networks for the Paso del Norte air basin to measure ambient concentrations of particulate pollution, ozone and its precursors (volatile organic compounds [VOCs] and NO_x), carbon monoxide, SO_2, lead, and air toxics. TCEQ, the city and county of El Paso, Ciudad Juárez's municipal government, and NMED operate Paso del

Norte air monitoring stations. Most stations include PM_{10}, carbon monoxide, and NO_x monitoring. Non-methane hydrocarbons are monitored at the Chamizal site in El Paso.

The total number of monitoring stations, exclusive of EPA's new $PM_{2.5}$ program, are 13 in the United States and six in Ciudad Juárez. Because new monitors are required to measure $PM_{2.5}$ under the new U.S. fine particle standards, TCEQ and NMED are in the process of establishing a new $PM_{2.5}$ monitoring network for El Paso and Doña Ana Counties. Once the networks are completely deployed and three years of data are collected, EPA will make nonattainment designations, likely sometime between 2003 and 2005. EPA and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) are working on a proposal to deploy $PM_{2.5}$ monitors in Ciudad Juárez.

There are eight $PM_{2.5}$ monitoring stations running or being made operational in Texas and two in New Mexico, for a total of 10 stations in the U.S. portion of Paso del Norte. It is expected that the fine fraction of PM_{10} may be more important for health risk assessment. The first report of $PM_{2.5}$ sampling in Texas, including one sample in downtown El Paso at the Tillman Health Center, appeared in December 1998 (Tropp 1998). The proposed regulation is that the 24-hour average $PM_{2.5}$ level should not exceed 65 $\mu g/m^3$ for a three-year average of annual 98th percentiles at any population-oriented monitoring site. The El Paso preliminary results show maxima above this level.

The severity of air quality problems in the Paso del Norte area have caused the federal governments of both the United States and Mexico to mandate that air quality control programs be implemented to attain health-based air quality standards. Through the U.S. Clean Air Act, TCEQ and NMED are required to submit State Implementation Plans (SIPs) to EPA that outline air pollution control programs for nonattainment areas. SEMARNAT worked with the state of Chihuahua and the municipal government of Ciudad Juárez to develop and implement the *Air Quality Management Program for the Improvement of Air Quality in Cd. Juárez 1998–2002* (SEMARNAT 1998).

Air quality planning and assessment are the first steps in the air quality management process. Monitoring, characterizing air quality, and developing and maintaining an emissions inventory, in conjunction with air quality modeling, are indispensable tools for the design and implementation of strategies that will achieve air quality standards established by both nations.

Emissions inventories allow for analysis of major emissions contributions and make it possible to determine the source categories for emissions control. Accurate emissions inventories in conjunction with air quality modeling are the tools employed to develop appropriate control strategies for attainment of air quality standards. Under the U.S. Clean Air Act, nonattainment areas must develop emissions inventories, conduct air quality modeling, and develop control strategies to achieve air quality standards. These analyses are submitted to EPA in the SIP. For Mexico, such tools constitute the methodological foundation of the air quality programs relying on environmental operating permits and statements of operation (for the industrial sector), Mexican official *norms,* emission factors, and mass balance modeling (Rincón 2002).

Emissions inventories and models have been more intensely examined in the 1990s than ever before. TCEQ periodically produces the El Paso Industrial Emissions Inventory. The most recent monitoring data are available at http://www.tceq.state.tx.us/index.html. This information, and the hydrocarbon source apportionment section of the 1996 Paso del Norte Ozone Study (Fujita 1998), was combined with the development of a grid map emission inventory for the entire Paso del Norte region (Haste, et. al. 1998).

Impact of Air Quality on Health in the Paso del Norte Air Basin

Although recognized to be important, the impact of air quality on human health in the Paso del Norte air basin has received only limited study. As a consequence, Paso del Norte-specific relationships between particulate concentrations and human health conditions are difficult to define. For example, particulates in the Paso del Norte air basin often include both urban and non-urban material that falls within the respirable size range. Although substantial literature documents the negative effects of dust on human health, few data exist concerning the degree to which the undisturbed desert lands contribute to particulate matter entrained in the air basin. In other areas of the western United States (Hefflin 1994; Schwartz 1999), the urban particle fraction (the amount of PM_{10}, $PM_{2.5}$, and total suspended particles in the air) alone has been shown to increase the mortality rate (Pope 1999).

Studies of the adverse effects of inhaled fine particles in Paso del Norte have appeared only recently. Hart, et al. (1999) report that the first medical studies to clearly relate contaminated air at El Paso and Ciudad Juárez to a broad range of respiratory problems, such as asthma, bronchitis, lung cancer, and emphysema, predated by 26 years the first study in 1991 of pediatric asthma by VanDerslice, et al. Hart, et al. (1999) modeled pediatric emergency room admissions in 1994 and 1995 for respiratory illness as a function of PM_{10} and ozone. In Paso del Norte, an increase in asthma-related emergency room visits was found to be associated with a decrease in dew point temperature on the same day and an increase in PM_{10} two days before. Risk assessment of exposure to fine particles in the Paso del Norte air basin has received little attention. Adverse health effects are commonly anticipated after exposure to inhalable fine particles produced by urban air pollutant sources, sandstorms, or a combination of the two (Hefflin 1994; Pope 1996). During the 1980s, attention focused on the air quality consequences of vehicles waiting to cross international bridges. Research explored such variables as numbers of vehicles in queue, waiting time, vehicle emissions, general air pollution, and health consequences for people living in and around the international bridges.

Roumiue, et al. (2003) studied the impact of PM_{10} and ozone on children's health in Ciudad Juárez. A relationship between ozone levels and emergency room visits by children for treatment of asthma and for treatment of respiratory infections has been identified. In children up to 5 years of age, the exposure to ozone is also related to infection in the lower respiratory tract with a late manifestation of four days. An increase of 20 ppm in the maximum eight-hour moving average prior to medical consultation is related to an increase of 12.7% in the risk of infection in the lower respiratory tract. The risk of infection is increased by 15% subsequent to an increase of 20 ppm in the one-hour daily maximum during the five days prior to medical consultation. No correlation is found between children's health and ambient PM_{10}. Multi-pollutant modeling with ozone yields a similar lack of correlation. In general, the air pollutants bear little relationship to respiratory-related mortality in the children sampled. Nevertheless, there are indications that elevated ambient PM_{10} could increase the risk of respiratory-related mortality in children aged one month to one year.

Air Quality Institutions in Paso del Norte

The 1990s in Paso del Norte were characterized both by more research and a much higher level of citizen and non-governmental organization (NGO) participation in air quality issues. For several years the Paso del Norte Air Quality Task Force has been active as a forum for debate and presentation of issues on both sides of the border. Meeting locales typically alternated between El Paso and Ciudad Juárez, with some meetings in Sunland Park, N.M. The meetings were attended by representatives of all local, state, and federal agencies having a vested interest on both sides of the border. The academic research community has been well-represented by local NGOs such as the Clean Cities Coalition and by international NGOs such as Environmental Defense.

The Paso del Norte Air Quality Task Force supported the formation of an International Joint Advisory Committee for the improvement of air quality in the air basin that covers Ciudad Juárez, El Paso, and Doña Ana County. The International Joint Advisory Committee now meets regularly to address air issues in the basin. The meeting notification and minutes distribution are managed through TCEQ's Region 6 office in El Paso (Valenzuela 1999).

One issue the task force lobbied for was commuter lanes to speed up bridge crossing and reduce transborder traffic waiting times. Various "fast identification" methods for pre-registered drivers and the commuter lane have been developed, according to a report to the Joint Air Quality Advisory Committee. Another issue addressed involves the export to Ciudad Juárez of U.S. automobiles that fail U.S. emissions tests. These issues cause a conflict between the economic gain from exportation of the vehicles versus efforts to reduce mobile source emissions. Other issues involve whether U.S. oxygenated fuels should be exported to Ciudad Juárez and what will replace MTBE (methyl-tertiary-butyl-ether) in the United States if this gasoline oxygenator is banned. Grassroots political action and citizen participation in ad hoc groups concerned about air quality have been important in raising public awareness about air quality in Paso del Norte.

A variety of public and private groups and organizations are now involved in air quality issues within Paso del Norte (Parks, et al. 2003). Some companies and utilities, through their environmental divisions, have participated in ways that have both present and future value. Two organizations with facilities on the Rio Grande have made their engineers available to display the most sophisticated modern air pollution control equipment to students in the area. One such company is Asarco, Inc. Its facilities essentially eliminated the hundreds of tons per day of sulfur oxides flowing from its smoke stack with "ConTop" smelting reactors, installed in 1993. The former waste product was then marketed as sulfuric acid. This facility is presently idle as a consequence of low copper prices and thus, for the first time in 100 years, is not contributing to air pollution. El Paso Electric Company has two plants in Paso del Norte that burn clean natural gas and have sophisticated temperature feedback controls to prevent NO_x emissions from exceeding regulatory limits. This utility has a pro-active environmental education program and successfully interacts with academic institutions in the area. The various public institutions involved in air quality in Paso del Norte are listed in Table 2.

Table 2. Institutions Involved in Air Quality in Paso del Norte

Local governments	Air Group, El Paso City-County Health Department Dirección de Desarrollo Urbano y Ecología del Gobierno del Municipio de Juárez
State governments	Dirección General de Desarrollo Urbano y Ecología del Gobierno del Estado de Chihuahua New Mexico Environment Department Texas Commission for Environmental Quality Western Governors' Association
Federal government	Instituto Nacional de Ecología Secretaría de Medio Ambiente y Recursos Naturales U.S. Environmental Protection Agency U.S. Centers for Disease Control and Prevention
International; U.S.-Mexico	Joint Advisory Committee for the Improvement of Air Quality in the Ciudad Juárez, Chihuahua; El Paso, Texas; Doña Ana County, New Mexico Air Basin
Academic institutions	Arizona State University New Mexico Institute of Technology New Mexico State University University of Texas at El Paso University of Utah San Diego State University Universidad Autónoma de Ciudad Juárez Southwest Consortium for Environmental Research & Policy
Non-governmental organizations	Border Health Research Center of the Paso del Norte Health Foundation Environmental Defense Clean Cities Coalition Physicians for Social Responsibility Paso del Norte Air Task Force

Source: Parks, et al. 2003

Future Issues of Air Quality Policy and Research

Uni-Basin Concept

Air pollution knows no political boundaries and travels across both state lines and the international border. El Paso, Ciudad Juárez, and Doña Ana County share a common air basin. Both policymaking and research would benefit from increased coordination between agencies with different local jurisdictions. Because of the international and state borders that lie within the air basin, binational, tristate cooperation is an element critical to solving the area's air quality problems. Cooperation will be needed in the implementation of an area-wide strategic plan (Rincón 2002).

Pollutant Credit Reduction Exchange

Emission trading is an innovative U.S. environmental policy designed to control air pollution through the exercise of free market forces. Currently, the United States has a viable market in permits for SO_2 traded at the Chicago Mercantile Exchange. Permit trading is currently used to allocate SO_2 emissions for coal-fired electric generating plants in the United States, and is gaining ground between U.S. and Canadian firms through a Pilot Emission Reduction Trading (PERT) program. Such a program has yet to be tried in the border area between the United States and Mexico. One idea is to develop a program for international exchange between the United States and Mexico in the El Paso-Ciudad Juárez air basin. Due to recent decentralization of air quality management efforts in Mexico, the Mexican government has established, under the overall supervision of the Instituto Nacional de Ecología (INE), a framework for a collective implementation action plan for air quality improvement. Under this new scenario, INE and SEMARNAT could examine the possibilities of a border emission permit trading mechanism (Ghosh 2001).

Environmental Impact Assessment

Transboundary Environmental Impact Assessments (TEIAs) are an important emerging approach intended to address transboundary environmental impacts of border industrial projects. Because there are fewer environmental regulations and construction permits are easier to obtain than on the U.S. side of the border, border industrial projects are located in Mexico rather than the United States (Rohy and Sweedler 2002).

Pollutant Emissions Inventory

An emissions inventory project for the entire country of Mexico has been initiated in the six Mexican border states and has recently included the four American border states (Fields 2003). On the Mexican side, INE is conducting an emissions inventory with technical assistance from EPA, the Western Governor's Association, and support from the Commission for Environmental Cooperation of North America.

Air Quality Sector of the Paso del Norte System Model

The air quality sector of the Paso del Norte system model captures a highly simplified version of how particulates are emitted and transported in the Paso del Norte air basin. Airborne particulates are generated by a mix of mobile sources (vehicle exhaust and traffic on unpaved roads), stationary urban sources (brick kilns, industrial activity, commercial activity, residences, and urban land), and stationary non-urban sources (irrigated land and dry land). Because there are important differences in the magnitude and frequency of particulate emissions on each side of the border, emissions from El Paso and Ciudad Juárez are computed separately before total particulate contributions to the air basin are computed. This approach enables the presentation of the possibility that emissions generated on either side of the border are transferred across the border. In static air conditions, particulate-laden air will tend to flow down slope to the Rio Grande from sources located within each community. At the Rio Grande, airborne particulates mix with those generated by vehicular traffic at border crossing bridges. During windy periods, particulates may be transported from one community to the other, blown completely out of the air basin, or transported into the air basin from adjacent dry land.

Explicit estimates of annual particulate emissions from mobile sources in both El Paso and Ciudad Juárez are based on computed vehicle kilometers traveled annually by a representative mix of vehicles (gasoline and diesel). Growth in vehicle kilometers traveled is linked directly to growth in urban land area computed in the land use sector of this volume (Chapter II-6).

Particulates generated by traffic on unpaved roads are estimated by computing the total length of all roads, estimating the portion that remains unpaved, and multiplying by the mean annual particulate mass emitted per kilometer. A portion of the new roads constructed in response to urban growth is assumed to remain unpaved unless a commitment is made to pave existing roads to reduce particulate emissions. The dynamic interaction between land use change and growth in road lane miles is described in more detail by Emmi (2003).

Implicit estimates of mobile emissions are included as part of the total emissions per employee working in manufacturing, trade, and other sectors of the economy such as commercial, retail, and service. The number of employees working in each sector of the economy is tracked in the economy model sector of this volume (Chapter II-4). The total emissions per employee also includes estimated contributions from localized stationary sources associated with each sector of the economy.

The brick kiln industry of Ciudad Juárez, however, is considered separately because this is a potential area for policy action to reduce particulate emissions. The number of kilns operating in the air basin is assumed to increase as new dwellings are added in response to population growth in Ciudad Juárez. Emissions per brick kiln are estimated from the results of research aimed at assessing strategies for reducing kiln emissions (Lara 2000).

Although it is relatively straightforward to estimate annualized patterns of particulate emissions within the air basin, it is much more difficult to compute aggregate, annualized particulate concentrations that can be effectively used in the quality of life model sector (Chapter II-1). Comparing historical emissions rates to records of particulate concentrations (Li, et al. 2000) provides a crude empirical basis for converting particulate emissions to particulate concentrations. Embedded in the calculation is an option to transfer a portion of the particulates generated in one city to the other city. Ultimately, mean annual particulate concentrations are computed separately for both El Paso and Ciudad Juárez. Although not fully implemented, options are also made available to adjust the way that a drier (or wetter) future climate might modify the relationship between emissions rate and mean annual concentration.

References

American Association for the Advancement of Science. 1965. *Air Conservation Committee Report.* Washington, D.C.: AAAS.

Dattner, S. 1994. *El Paso/Juárez PM_{10} Receptor Modeling Feasibility Study.* Austin, Tex.: Texas Commission on Environmental Quality.

El Paso Metropolitan Planning Organization. 1998. *El Paso Metropolitan Transportation Plan.* El Paso, Tex.: El Paso Metropolitan Planning Organization.

Emerson, P. M., C. F. Angulo, C. L. Shaver, and C. A. Rincón. 1998. "Managing Air Quality in the Paso del Norte Region." In *Environmental Management on North America's Borders,* R. Kiy and J. D. Wirth, eds. College Station, Tex.: Texas A&M University Press.

Emmi, P. C. 2003. "Coupled Human–Biologic Systems in Urban Areas: Towards an Analytical Framework Using Dynamic Simulation." Proceedings of the 21st International System Dynamics Conference, New York, 20–24 July.

Fujita, E. 1998. *Hydrocarbon Source Apportionment for the 1996 Paso del Norte Ozone Study.* Reno, Nev.: Energy and Environment Engineering Center, Desert Research Institute.

Fields, P. 2003. "Mexico's National Emissions Inventory Workshop." Chihuahua, Chih., 5–6 August.

Ghosh, S. 2001. "Development of a Program for International Emissions Trade Exchange Between the United States and Mexico." Paper presented at the Mexican-American Border Workshop, Mexicali, B.C, March.

Gray, R. W. 1989. "Ozone Map." Cited 28 July 2004. http://www.ozonemap.org.

Gray, R. W., J. Reynoso, C. Diaz Q., and H. Applegate. 1989. *Vehicular Traffic and Air Pollution in El Paso-Ciudad Juárez.* El Paso, Tex.: Texas Western Press.

Hart, R., J. VanDerslice, B. Vera, C. Gotway-Crawford, S. Kieszak, R. Philen, and M. Maceehin. 1999. *Ambient Air Quality and Acute Pediatric Respiratory Illness in the Paso del Norte Airshed.* Atlanta: National Center for Environmental Health, Centers for Disease Control.

Haste, T. L., N. Kumar, L. R. Chinkin, P. T. Roberts. M. Saeger, and S. Mulligan. 1998. "Compilation and Evaluation of a Gridded Emission Inventory for the Paso del Norte Area." Sonoma Technology, Inc. Report No. STI-998110-188-FR.

Hefflin, B. J., B. Jalaludin, E. McClure, N. Coob, C. A. Johnson, L. Jecha, and R. A. Etzel. 1994. "Surveillance for Dust Storms and Respiratory Diseases in Washington State, 1991." *Archives of Environmental Health* 49:170–174.

Lara, A. S. 2000. "Clean Air, Even from Incomplete Combustion." Paper presented at SCERP Technical Conference, Ciudad Juárez, Chih., 11–13 October.

Li, W. W., R. M. Currey, V. H. Valenzuela, H. L. C. Meuzelaar, S. A. Sheya, J. R. Anderson, S. Banerjee, and J. B. Griffin. 2000. "The Paso del Norte Air Research Program." SCERP Technical Conference, Ciudad Juárez, Chih., 11–13 October.

Li, W-W., R. Orquiz, J. H. Garcia, T. T. Espino, N. E. Pingitore, J. Gardea-Torresday, J. Chow, and J. G. Watson. 2001. "Analysis of Temporal and Spatial Dichotomous PM Air Samples in the El Paso-Cd. Juárez Air Quality Basin." *Journal of the Air and Waste Management Association* 51:1551–1560.

Parks, N. J., W. Li, C. D. Turner, R. W. Gray, R. Currey, S. Dattner, J. Saenz, V. Valenzuela, and J. A. VanDerslice. 2003. "Air Quality in the Paso del Norte Airshed: Historical and Contemporary." Pages 81–95 in *The U.S. Mexican Border Environment: Air Quality Issues Along the U.S. Mexican Border* SCERP Monograph Series No. 6, A. Sweedler, ed. San Diego, Calif.: SDSU Press.

Pope, C. A. 1996. "Particulate Pollution and Health: A Review of the Utah Valley Experience." *Journal of the Exposure Analysis and Environmental Epidemiology* 6: 23–34.

Pope, C. A., R. W. Hill, and G. M. Villegas. 1999. "Particulate Air Pollution and Daily Mortality on Utah's Wasatch Front." *Environmental Health Perspectives* 107(7): 567–573.

Rincón, C., and P. Emerson. 2000. "Binationally Managing Air Quality in the U.S.-Mexico Borderlands: A Case Study." *Borderlines* 8(1).

Rincón, C. A. 2002. "Solving Transboundary Air Quality Problems in the Paso del Norte Region." Pages 255–280 in *Both Sides of the Border,* L. Fernández and R. T. Carson, eds. New York: Kluwer Academic Publishers.

Rohy, D., and A. Sweedler. 2002. "Environmental Impacts of Existing and Proposed Power Plants in the California-Baja California Border Region and Development of a Transboundary Environmental Impact Assessment Process." SCERP Project Number E-02-02. http://www.scerp.org/scerp/projs/02rpts/E-02-2ab.htm.

Romieu, I., A. M. Ramírez, M. H. Moreno, V. Barraza A., C. L. Hernández, and A. L. Carbajal. 2003. *Impactos de la contaminación atmosférica en la morbilidad y mortalidad de la población infantil de Ciudad Juárez, Chihuahua, México.* Montréal: Commission for Environmental Cooperation.

Schwartz, J., G. Norris, T. Larson, L. Sheppard, C. Claiborne, and J. Keoning. 1999. "Episodes of High Coarse Particle Concentrations Are Not Associated with Increased Mortality." *Environmental Health Perspectives* 107(5): 339–342.

Secretaría de Medio Ambiente y Recursos Naturales. 1996. "Programa Frontera XXI." First edition, November.

Secretaría de Medio Ambiente y Recursos Naturales. 1998. *Air Quality Management Program for Ciudad Juárez,* 1998–2002. Mexico City: SEMARNAT.

Suarez y Toriello, E., and O. Chavez. 1996. *Profile of the United States-Mexico Border.* Ciudad Juárez, Chih.: FEMAP.

Texas Natural Resource Conservation Commission. 1991. *Revision to the Texas State Implementation Plan for PM_{10} for El Paso, TX.* Austin, Tex.: TNRCC.

Tropp, R. J., S. D. Kohl, J. C. Chow, and C. A. Gfrazier. 1998. *Final Report for the Texas $PM_{2.5}$ Sampling and Analysis Study.* Desert Research Institute Document No. 6570-685-7770.1f (15 December).

Valenzuela, V. 1999. *Joint Air Quality Commission Meeting Notification and Proceedings.* El Paso, Tex.: Texas Natural Resource Conservation Commission.

Velázquez, A. G. 2002. "Ciudad Juárez, Programs for Dust Control." Paper presented at Dust Control Workshop, Santa Teresa, N.M., 11 December.