Executive Summary

Air Quality in the United States-Mexican Border Region

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Abstract

Air pollution is one of the most important environmental issues in the U.S.-Mexican binational region. It is ubiquitous but includes a variety of types, sources, and effects. It threatens economic development and human and environmental health. It originates from, flows to, and needs solutions from both sides of the border. And it is worsening in many cases for a variety of reasons.

The region surrounding the 1,952-mile long border has the fastest growing population in North America. Its growth rate is almost double the Mexican rate and the region includes the cities of the Lower Rio Grande Valley, which are growing at a blistering pace. The border population is expected to double from its current level of approximately 12 million to more than 24 million by 2025. Most of that growth, which will occur faster in Mexico than the United States, will be in the urban twin-city pairs along the border.

The 1992 passage of the North American Free Trade Agreement (NAFTA) and its current implementation exacerbates the already-fast growth rate. The border is the gateway—some would say "doormat"—for the North American trade of agricultural products, tourism, raw materials, and the finished products of a large and still-growing manufacturing and assembly industry, known as the maquiladora industry, which is located mostly in the border region.

The number of car, small truck, and heavy-duty truck crossings to accommodate the industry and trade increases without commensurate infrastructure improvements or regulatory relief, causing congestion at the border ports of entry and intensifying air pollution in local areas.

The region remains impoverished compared to the rest of the United States. Unemployment is higher and wages are lower—and continue to decrease—relative to the whole of the United States. The lower salary rates are reflected in the tax base and coffers of the governments, and this translates into less means to monitor, understand, address, and even publicize the issues.

The region has some indigenous fossil fuels. Natural gas exists in Texas, Coahuila, Nuevo León, and Tamaulipas; Chihuahua and Coahuila have coal; and Texas has petroleum. Some renewable energy sources exist throughout the region, including solar, wind, and geothermal. The region's limited but rapidly increasing electrical generating facilities depend primarily on oil and coal (Carbón I and II) in Mexico and oil and gas in United States. In Baja California most of the current and planned power plants are powered by natural gas imported from the United States. The border region continues to import both fuels and electrical power.

Resumen Ejecutivo

Calidad del Aire en la Región Fronteriza México-Estados Unidos

Resumen

Entre los problemas de la región binacional México-Estados Unidos, la contaminación del aire se sitúa entre los de más alta prioridad. Es ubicua pero incluye una variedad de tipos, fuentes y efectos. Amenaza el desarrollo económico así como la salud humana y ambiental. Se origina, fluye y necesita soluciones desde ambos lados de la frontera. Y está empeorando en muchos casos debido a causas diversas.

La región que rodea la frontera con 1,952 millas de largo, tiene quizás la población con más rápido crecimiento en Norteamérica. Su tasa de crecimiento es casi el doble que la de México y la región incluye las ciudades situadas en la parte baja del Valle de Río Grande, las cuales crecen a un paso vertiginoso. Se espera que la población duplique su número actual de aproximadamente 12 millones a más de 24 millones para el año 2025. La mayoría de ese crecimiento, el cual ocurrirá más rápido en México que en los Estados Unidos, será en los pares urbanos de ciudades gemelas ubicadas en la frontera.

La aprobación en el año de 1992 del Tratado de Libre Comercio (TLC) y su actual implementación, acelera el ya rápido índice de crecimiento. La frontera es el medio de acceso–algunos dirán "la alfombra de bienvenida"–para el comercio norteamericano de productos agrícolas, turismo, materias primas, y los productos terminados de una grande y todavía creciente industria de manufactura y ensamble como lo es la industria maquiladora, la cual se sitúa en su mayor parte en la región fronteriza. El número de autos y camiones de carga ligera y pesada que deben cruzar para satisfacer las necesidades de la industria aumenta sin las mejoras proporcionales de infraestructura o regulatorias, causando congestión en los accesos fronterizos y la intensificación de contaminación aérea en áreas locales.

La región permanece empobrecida comparada con el resto de los Estados Unidos. El desempleo es más alto y los salarios más bajos–y continúan disminuyendo–en relación con la totalidad de los E.U. Los bajos salarios se reflejan en la base tributaria así como en los fondos de los gobiernos, y esto se traduce en menos recursos para monitorear, entender, atender, y hasta difundir los asuntos en cuestión.

AIRBASINS

The region has a number of officially recognized and informally designated common binational airbasins—geographic regions defined by airflows. An airbasin is usually determined by a mountainous circumference that limits airflow, making activities in any part of the basin interdependent on activities in others.

The binational airbasins are characterized by their topography, climate, and weather. Most are defined by mountain ranges, predominant but seasonally shifting winds, and potentially strong thermal inversions—locations where cooler air masses trap warmer air pockets after accumulating local sources of pollution until the temperature gradient equalizes. For example, residents of San Diego and Tijuana share an airbasin since a coastal mountain range somewhat limits movements of air in the area. Daily reciprocal coastal-offshore breezes mix the local air from as far north as Los Angeles and as far south as Ensenada, while predominately westerly winds eventually move the air to the east. The Imperial County-Mexicali airbasin is low (partly below sea level), hot (over 100 degrees Fahrenheit on summer days), and bounded by mountains to the east and west. The El Paso-Ciudad Juárez, or Paso del Norte, airbasin is defined by predominant westerly winds and a pass in the mountain range through which the winds are channeled. The same predominant winds cross the Big Bend region—a mix of mountains and plateaus—making it hard to determine where pollutants present there originate. Finally, the Lower Rio Grande Valley is flat, more tropical, and has coastal breeze influences from the Gulf of Mexico.

In the case of the U.S.-Mexican border region, there are several valleys transversed by the political border in which cities have developed on both sides (San Diego-Tijuana, El Paso-Ciudad Juárez, Calexico-Mexicali). Here the residents of both cities from the two countries share the same atmospheric space; thus, activities in one directly affect the other. Since these twin cities have developed under distinct governmental regulations, as well as under very different economic and social conditions, the sources of air pollution on each side are different. Just as the pollutants generated on one side affect the other, solutions need to be determined, understood, and implemented binationally. Examples of border airbasins are described in this volume geographically from west to east, including San Diego-Tijuana, Imperial County-Mexicali, the Paso del Norte area of El Paso-Ciudad Juárez, the Big Bend region, and the Lower Rio Grande Valley.

Types of Pollutants and Their Effects

The binational airbasins are plagued by dangerous levels of several air pollutants that originate on both sides of the border. Some are monitored to some degree under efforts to reach air quality goals. The United States Environmental Protection Agency (EPA) uses six "criteria pollutants" as indicators of air quality and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called National Ambient Air Quality Standards. Each state also has standards that may meet or exceed the federal standard. Likewise, the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) has its own standards that in some cases match, but in others exceed, United States standards. The table below identifies air chemistry components of greatest concern to the various regions. The standards range from attainment of standards to moderate nonattainment, to strict restrictions on additional emissions due to severe nonattainment.

Table 1. Border Air Quality Goal Attainment Status

Airbasin	Ozone (O_3)	Carbon Monoxide (CO)	Particulate Matter (PM)	Sulfur Dioxide (SO_2)
San Diego-Tijuana	Serious	Transitional	Attainment	Attainment
Imperial Valley-Mexicali	Transitional	Transitional	Moderate	Attainment
Douglas-Agua Prieta	Attainment	Attainment	Moderate	Primary
El Paso - Ciudad Juárez	Serious	Moderate	Moderate	Attainment
Big Bend Park region	Attainment	Attainment	Attainment	Attainment
Lower Rio Grande Valley	Attainment	Attainment	Attainment	Attainment

When an area does not meet the air quality standard for one of the criteria pollutants, it may be subject to the formal rulemaking process that designates it as "nonattainment." The Clean Air Act further classifies ozone, carbon monoxide, and some particulate matter nonattainment areas based on the magnitude of an area's

problem. Nonattainment classifications may be used to specify what air pollution reduction measures an area must adopt and when the area must reach attainment. The following is a discussion of the standards, designations, and classifications of these areas. More and current information may be found on the websites of the EPA at www.epa.gov, SEMARNAT at www.semarnat.gob.mx, and the Centro de Información sobre Contaminación de Aire/Center for Information on Air Pollution at www.epa.gov/ttn/catc/cica.

Ozone

Ozone (O_3) is a photochemical oxidant and the major component of smog. While O_3 in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of O_3 at ground level are a major health and environmental concern. O_3 is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOC) and oxides of nitrogen (NO_X) in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak O_3 levels occur typically during the warmer times of the year. Both VOCs and NO_X are emitted by transportation and industrial sources. VOCs are emitted from sources as diverse as automobiles, chemical industries, dry cleaners, paint shops, and other businesses using solvents.

The reactivity of O_3 causes health problems because it damages lung tissue, reduces lung function, and predisposes the lungs to sensitivity to other irritants. Scientific evidence indicates that ambient levels of O_3 not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children as well. Exposure to O_3 for several hours at relatively low concentrations has been found to reduce lung function significantly and induce respiratory inflammation in normal, healthy people during exercise. This decrease in lung function is generally accompanied by symptoms including chest pain, coughing, sneezing, and pulmonary congestion.

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated CO levels can cause impairment of visual perception, manual dexterity, learning ability, and performance of complex tasks. More than three-quarters of the CO emissions nationwide are from transportation sources; motor vehicles on highways contribute the most emissions. Thus, the focus of CO monitoring is on traffic-oriented sites in urban areas where the main source is motor vehicle exhaust. Other major CO sources are woodburning stoves, incinerators, and industrial activities. The National Ambient Air Quality Standard for carbon monoxide over an eight-hour average is 9ppm, or parts per million (also equal to 10 micrograms per cubic meter).

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish, highly reactive gas present in all urban atmospheres. NO_2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to O_3 and acid deposition, or acid rain (which causes acidification of lakes and streams and can damage trees, crops, and historic buildings and statues), and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant nitric oxide (NO). Both NO and NO_2 (known collectively as NO_X) play a major role, together with VOCs, in the atmospheric reactions that produce O_3. NO_X forms when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion in electric utility and industrial boilers.

Sulfur Dioxide

High concentrations of sulfur dioxide (SO_2) affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children, and the elderly. SO_2 is also a primary contributor to acid rain. In addition, sulfur compounds are one of the causes of impaired visibility in many regions of the country. This is especially noticeable in national parks. Ambient SO_2 results largely from stationary sources such as coal and oil combustion sites, steel mills, refineries, pulp and paper mills, and non-ferrous smelters.

Particulate Matter

Particulate matter refers to dust, dirt, soot, smoke, and liquid droplets directly emitted into the air by sources like factories, power plants, cars, construction activity, fires, and natural windblown dust. Particles formed in the atmosphere by condensation or by the transformation of emitted gases such as SO_2 and VOCs are also considered particulate matter.

Based on studies of human populations exposed to high concentrations of particles (sometimes in the presence of SO_2) and laboratory studies of animals and humans, there are major concerns for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature death. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include asthmatics, the elderly, children, and individuals with chronic obstructive pulmonary or cardiovascular disease, or influenza. Particulate matter also damages materials and is a major cause of visibility impairment in the United States. The smallest particles pose the greatest health risk because they can be aspirated deep into the lungs with each breath and can evade the respiratory system's natural cleansing abilities. Because some are produced by combustion, they are carcinogenic and mutagenic and thus, they can cause substantial ill-

nesses, acute respiratory diseases, and premature death.

Particulate matter is defined by aerodynamic diameter: PM_{10} are those particles less than 10 microns; PM_{coarse} are those particles between 10 microns and 7.5 microns; and $PM_{2.5}$ or PM_{fine} are those less than 2.5 microns.

Lead

Even low doses of lead damage the central nervous system. Recent studies have also shown that lead may be a factor in high blood pressure and in subsequent heart disease in middle-aged males. Lead gasoline additives, non-ferrous smelters, and battery plants are the most significant contributors to atmospheric lead emissions. In 1993, transportation sources contributed 33% of the annual emissions, down substantially from 81% in 1985. Total lead emissions from all sources dropped from 20,100 tons in 1985 to 4,900 tons in 1993. The decrease in lead emissions from highway vehicles accounts for essentially all of this decline.

Sources and Fates

The primary sources of air pollution in the region are dust, combustion of fuels, open burning, and vehicles and other mobile sources. The predominant economic activities in the region—agriculture, manufacturing, and residential development—create a mix of pollutants. Sources particular to these arid, border twin-cities include:

- Agricultural practices such as plowing, rotating, and weeding soils; airborne pesticide application, fallowing of fields, and burning of wastes
- Natural geologic sources such as sands and clays from unpaved roads, dried lakes, and streambeds
- Industrial activities such as mining, refining, wastewater treatment, and geothermal energy generation
- Food cooking, especially outdoors and over wood-burning fires

Local meteorological and geographic conditions determine much of the effect of pollutants. Strong winds tend to pick up and suspend large particles longer, moving them greater distances. Some pollutants, such as ozone, are created and destroyed daily, but may circulate in an area due to local wind patterns both on the ground and in the air. Still other pollutants combine or dissociate to make new compounds. Details about specific sources, transport, fates, and offspring are found in each chapter.

Binational Approaches to Address and Resolve Air Pollution

All efforts to address air quality issues in the border region begin with binational cooperation in monitoring and analyzing air. The 1990s saw new initiatives along the border and even entire databases developed out of the effort. The Centro de Información sobre Contaminación de Aire (CICA) is dedicated to air quality issues and data in the border region. The EPA has developed several technical tools, including source databases, dispersion models, and processors of meteorological data, some of which are available in Spanish specifically for analytical use in the border region.

Remedies revolve around informing the public, as well as planning and implementing optimal solutions. Outreach mechanisms include public service announcements and interpretation of local, real-time conditions by weather reports on news programs. For example, a website provides real-time information about ozone conditions and impacts in the Paso del Norte. Strategic planning and prioritization of implementation strategies are also being conducted. The EPA and SEMARNAT created a number of working groups as part of their binational Border XXI Program to address concerns in the region jointly. The Air Working Group, a Joint Task Force in the Paso del Norte, and later a NAFTA-recognized Joint Advisory Council in the Paso del Norte wrote a remediation plan that is slowly being funded and implemented. A Binational Air Quality Alliance in the San Diego-Tijuana region is also engaged in mid-term planning for solutions to local challenges. United States legislation has included the Border Smog Reduction Act of 1998 (HR 8), sponsored by then-Congressman Brian Bilbray, to mandate that Mexican vehi-

cles regularly spending time in the United States meet California air emissions standards. Other coalitions are attempting to introduce sufficient alternative fuel infrastructure to power a fleet of vehicles. Oxygenated additives are used in some areas threatened by CO and O_3 hazards. These are just a few examples of the ongoing binational efforts to address the pressing concern of air pollution in the border region.

The Role of Southwest Center For Environmental Research Policy

SCERP has successfully completed numerous studies on air quality, alternative fuel, energy conversion, global climate change, and implementation strategies. In just the last five years, SCERP has conducted:

- Air Quality/Meteorology Projects on almost all air chemistry components for the Paso del Norte, San Diego-Tijuana, Mexicali-Calexico, Big Bend, Hidalgo-Reynosa, and Nuevo Laredo, New Mexico regions, the results of which are used to prioritize air cleanup implementation strategies
- A Binational Air Emissions Permit Trading study to harness market forces to clean emissions and save money in the entire border airbasin
- Major Carbon Sequestration efforts in Mexicali and Ojinaga by growing trees with partially treated wastewater
- Brick-Making Kiln studies and created designs to make brick-firing more efficient, cost-effective, cleaner, and safer for the operators
- Global Climate Change studies to investigate feedbacks from land use patterns, vegetation cover, soil, moisture, and desert temperatures; accelerated changes are used to alert local planners and resource managers

SCERP has also:

- Built and redesigned Domestic Heating Unit Efficiency prototypes to lower emissions and improve home heating efficiency

- Collected Car, Light Truck, and Diesel Truck Emissions and Activity data for regional mobile-emissions inventories and models
- Developed Air Quality Improvement Willingness to Pay models to assess drivers' abilities to change maintenance and driving patterns and to plan the most cost-effective policies
- Created Hybrid Wind-Generator engineering and hardware to provide renewable and reliable energy to communities off the traditional grid

SCERP also sponsored its third Border Institute, "Trade, Energy and the Environment: Challenges and Opportunities in the Border Region, Now and in 2020," to address the relationship of air quality to energy development and the long-term policy solutions to air quality issues. Those proceedings are included in another SCERP monograph.

Summary of Papers

In "Air Quality in the California-Baja California Border Region," authors A. Sweedler, M. Fertig, and K. Collins from San Diego State University and M. Quintero-Núñez from Universidad Autónoma de Baja California give a comprehensive description of the climate geomorphology, economy, transportation, and energy setting and the resultant air quality conditions in California's and Baja California's two airbasins—San Diego-Tijuana and Imperial Valley-Mexicali. Rapid population growth, expanded industrialization—including that of maquiladora plants—and extreme congestion at border crossings by cars and light- and heavy-duty trucks, exacerbate an already dire situation. While the region has significant solar, geothermal, and wind resources, it continues to import fuels and electricity. Monitoring of air quality at binational sites has improved dramatically in the last five years, contributing to a better understanding of airbasin dynamics. Future progress on the overall issue is possible, thanks to past efforts to monitor and model the airbasin.

An extensive study by SCERP to understand the types, source apportionment, and fates of particulates in the Paso del Norte is ongoing and will be the subject of a subsequent monograph.

However in this volume, "Air Quality in the Paso del Norte Airshed: Historical and Contemporary," by J. Parks, W. Li, C. D. Turner, R. W. Gray, R. Currey, S. Dattner, J. Saenz, V. Valenzuela, and J. A. VanDerslice of the University of Texas at El Paso, provides an overview of the Paso del Norte airshed region, which is comprised of Ciudad Juárez, Chihuahua; El Paso, Texas; and Doña Ana County, New Mexico. The authors identify stakeholders and provide a framework for industry, academia, non-governmental advocates, and government agencies at various levels to collaborate on air issues. They also provide a number of important websites for information.

S-M. Lee and H. J. S. Fernando at Arizona State University declare the need to accurately understand and model planetary boundary layer behavior to understand the fate of air pollution in their contribution to this volume, "Planetary Boundary-Layer Structure of the Paso del Norte Airshed: A Numerical Study." The paper describes the meteorologically determined fate of airborne contaminants. Heat, moisture, wind direction, and speed all affect trajectories from sources and fall-out rates of the components. The three-dimensional model-driven simulations from two different schemes in various seasons closely match actual sounding measurements. Among the conclusions is that there is a need for more data from carefully planned experimental designs. The value of such models is the ability to begin to ask air quality improvement questions including what if these sources are prohibited, scheduled, relocated, and/or minimized? The trajectory models provide a necessary understanding of fates, alludes to effects, and discerns populations at risk.

Another approach to air pollution issues is provided by R. Okrasinski and J. Greenlee of New Mexico State University in their report, "Correlation of Wind Flow and Visibility at Big Bend National Park." They ask where contaminants in a particular area originate and examine the air chemistry in the Big Bend region—which contains national and state parks, monuments, preserves, and refuges on both sides of the border and is plagued by poor visibility caused to some degree by fine particulates (0.4 to 0.7 microns). Specifically, they measure penetration of visible light using transmissometers to determine the deciview (visibility units) at various locations. Then, using diffusion models corrected with radiosonde

station data, they match signatures with probable sources within a 600km radius to attribute the relative contribution from each. Dramatic seasonal variability creates the best conditions when predominant winds are from the north and west, and the worst conditions when from the east and south. The Mexican coal-burning plants known as Carbón I and II, long suspected of being major sources of air pollution in the Big Bend National Park, were absolved of primary responsibility while sources in eastern Texas are questioned. Such understanding is critical to binational solutions. This study demonstrates the importance of applied scientific research to understanding these complex problems.

Finally, "Characterization and Dynamics of Air Pollution in the Lower Rio Grande Valley," by G. Mejia-Velazquez, S. Sheya, J. Dworzanski, M. Rodriguez-Gallegos, D. D. Tajeda-Honstein, J. M. Cardona-Carrizalez, and H. L. C. Meuzelaar of the University of Utah, takes a comprehensive look at critical pollutants, VOCs, particulates, and NO_X. They describe transient episodes of relatively high particulate concentrations to determine causes and an outlook for the future. Using receptor sensors (size distribution scales and particle counters), meteorological studies, principal component analysis, and a photochemical model, the researchers were able to identify several sources, including mobile sources, a PEMEX refinery, and a power plant (in descending order), as the primary causes. As population and trade increase, the contribution from traffic and industry is expected to push the region into nonattainment of standards.

Overall, the papers illustrate the diverse challenge to air quality within the border region alone, as well as the need to comprehensively understand the situation in order to tailor remedies to the specific, local situation. The papers also exemplify that the political will necessary to address the issue does exist and is effective when applied. Outreach to the local community to promote their understanding and involvement is a common theme in all reports. These studies also show the importance of the existence of a consortium of United States and Mexican universities within the border region that can facilitate a coordinated, multidisciplinary approach to a focused issue like air. At the same time, these studies show how this medium is so intertwined with others. Only through a binational, comprehensive, multimedia approach can the complexity of border environmental issues be addressed.