II

A Tale of "Three" Cities: Air Quality Improvement Efforts in the Arizona-Sonora Border Region

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Abstract

This chapter compares and contrasts air quality improvement efforts in three pairs of sister cities along the Arizona-Sonora border: Douglas-Agua Prieta, Ambos Nogales, and Yuma-San Luis Río Colorado (SLRC). Several patterns of successes and challenges emerge, pointing to various lessons of relevance to the rest of the U.S.-Mexican border.

These sister cities share common sources of particulate matter (PM) pollution, which is the most important air pollutant impacting public health along the Arizona-Sonora border. Major sources of PM pollution include unpaved roads, vehicle emissions, traffic congestion, soil erosion, and residential burning of garbage and wood. Emissions from agricultural tilling and agricultural burning practices are an important source in Yuma-SLRC.

Air quality monitoring and air quality trends are quite different in each sister city pair. Douglas has complied with applicable air quality standards for PM_{10} and $PM_{2.5}$ (PM that measures 10 microns and 2.5 microns or less in diameter, respectively). Agua Prieta shows PM_{10} violating the applicable air quality standards (Mexican Allowable Limits). Yuma is being reclassified from a nonattainment area to a maintenance area.

While Nogales, Arizona, has not violated the annual PM_{10} standard since the early 1990s, it has shown an upward trend since 1997. In Nogales, Sonora, both the 24-hour PM_{10} concentrations and the annual averages are generally slightly higher than those in Nogales, Arizona, with the allowable limits regularly being violated.

Binational air quality studies are at various stages of work in each of the three sister-city pairs. The binational study for Ambos Nogales was published in 1999; in Douglas-Agua Prieta, the monitoring and emissions inventory have been completed; and in Yuma-SLRC meteorological data collection has begun.

It has been possible to conduct the binational air studies with the same phases in each area. Differences in population and economic growth, as well as air quality compliance status and trends over time, however, will require different approaches to emissions reduction activities in each of the three areas.

Several interesting conclusions emerge from comparing the experiences of these three sister-city pairs. Most importantly, social infrastructure has been a common element in successful efforts. Social infrastructure is the networks of people and institutions that work together toward a common goal. Where relevant, established social infrastructure, exists local leadership to implement air quality improvement actions comes along naturally. Another key factor is effective public outreach. One important, common experience of successful social infrastructures working on air quality in the Arizona-Sonora border region is that local Sonoran residents have participated in these collaborative efforts as equal partners to their Arizona counterparts.

This chapter notes that each major emissions source exists in its own framework of laws, policies, social driving forces, levels of relevant governmental authority, and the roles of individuals. To address any source successfully, the participants in that effort must first fully understand that framework, but then must also exercise out-of-the-box thinking about the particular emissions source in question. Second, the design and targeting of emissions reduction activities is something that can be effectively controlled by local participants, with measurable air quality improvements possible as a result. Third, other important factors affecting air quality are often beyond local or even state-level participant's control, in particular, weather patterns, population growth, and economic growth. Fourth, because national policy initiatives often tend to be informed by a perspective that focuses on the grand scale and large populations, the needs of rural areas can be overlooked or lost amid the many competing priorities.

Finally, while financing air quality projects is essential to real success, it is not necessarily the first step. The effective establishment of a relevant social infrastructure may be essential prior to obtaining and effectively using substantial levels of funding and essential to the long term success of any project.

Historia de "Tres" Ciudades: Esfuerzos para mejorar la Calidad del Aire en la Región Fronteriza Sonora-Arizona

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Resumen

Este capítulo compara y contrasta los esfuerzos para mejorar la calidad del aire en tres pares de ciudades hermanas a lo largo de la frontera de Sonora-Arizona: Agua Prieta-Douglas, Ambos Nogales, y San Luis Río Colorado (SLRC)-Yuma. Surgen diversos patrones de éxitos y retos que apuntan a varias lecciones de relevancia para el resto de la frontera de México-Estados Unidos.

Estas ciudades hermanas comparten fuentes comunes de contaminación provenientes de materia particulada (PM, por sus siglas en inglés), la cual es el contaminante más importante del aire que impacta la salud pública a lo largo de la frontera de Sonora-Arizona. Las fuentes principales de contaminación de PM incluyen las calles sin pavimentar, las emisiones vehiculares, la congestión del tráfico, la erosión del suelo y el quemado de basura residencial y madera. Las emisiones de las prácticas de cultivos y quema agrícolas, son fuentes importantes en SLRC-Yuma.

El monitoreo de la calidad del aire y las tendencia de la calidad del aire son bastante diferentes en cada par de ciudades hermanas. Douglas ha cumplido con los estándares aplicables de la calidad de aire para PM_{10} y $PM_{2.5}$ (PM que mide 10 micrones y 2.5 micrones o menos en diámetro, respectivamente). Agua Prieta muestra que el

PM_{10} viola los estándares aplicables a la calidad del aire (Límites Permisibles en México). Yuma está en proceso de reclasificación de ser un área de no cumplimiento a ser área en mantenimiento.
Aunque en Nogales, Arizona no se han violado los estándares anuales para PM_{10} desde principios de la década de 1990, sí ha mostrado una tendencia ascendente de PM10 desde 1997. En Nogales, Sonora, tanto las concentraciones de PM_{10} durante 24 horas como los promedios anuales son por lo general ligeramente más altos que aquellos en Nogales, Arizona, con los límites permisibles regularmente violados.

Los estudios binacionales de la calidad del aire se encuentran en diversas fases de trabajo en cada uno de los tres pares de ciudades hermanas. El estudio binacional de Ambos Nogales fue publicado en 1999; en Agua Prieta-Douglas, el monitoreo y el inventario de emisiones han sido completados; y en SLRC-Yuma la recopilación de información metereológica ha sido iniciada.

Ha sido posible llevar a cabo los estudios binacionales del aire con las mismas fases en cada área. Sin embargo, las diferencias y el crecimiento poblacional y económico, así como el estado de cumplimiento y tendencias en el área de la calidad del aire a través del tiempo, requerirán diferentes enfoques de las actividades para la reducción de emisiones en cada una de las tres áreas.

Diversas conclusiones interesantes emergen al comparar las experiencias de estos tres pares de ciudades hermanas. Lo más importante, la infraestructura social ha sido un elemento común en los esfuerzos que han sido exitosos. La infraestructura social es la red de personas e instituciones que trabajan conjuntamente hacia un fin común. En donde existe una infraestructura social relevante y establecida, el liderazgo local para implementar las acciones para mejorar la calidad del aire se da de manera natural. Otro factor clave es un enlace comunitario efectivo. Una experiencia importante y común de las infraestructuras sociales, es que trabajan en la calidad del aire en la región fronteriza de Sonora-Arizona, es que los residentes locales de sonorenses han participado en estos esfuerzos de colaboración como socios iguales a sus homólogos en Arizona.

Este capítulo establece que cada fuente prioritaria de emisiones existe en su propio marco jurídico, políticas, matrices, niveles de autoridad gubernamental relevante y el desempeño de los individuos. Para poder abordar cualquier fuente exitosamente, los participantes en ese esfuerzo deberán primero entender completamente ese marco, pero después también deberán pensar fuera de ese marco opiniones sobre la fuente particular en cuestión. Segundo, el diseño y enfoque de actividades de reducción de emisiones es algo que los participantes locales pueden controlar de modo eficaz con mejoras en la calidad del aire que se pueden medir. Tercero, otros factores importantes que afectan la calidad del aire están fuera del control de la participación ciudadana local y hasta estatal, en particular, en patrones metereológicos, crecimiento poblacional y crecimiento económico. Cuarto, ya que las iniciativas nacionales de políticas por lo general tienden a estar informadas por una perspectiva que se enfoca en la gran escala y poblaciones numerosas, las necesidades de las áreas rurales pueden pasar desapercibidas o perderse entre las diversas prioridades en competencia.

Finalmente, mientras que el financiamiento de los proyectos de la calidad del aire es esencial para el éxito real, no es necesariamente el primer paso. El establecimiento eficaz de una infraestructura social relevante puede ser esencial previo a obtener y usar efectivamente niveles substanciales de financiamiento y esencial para el éxito a largo plazo de cualquier proyecto.

Introduction

Geography of the Arizona-Sonora Border Region

The Arizona-Sonora border region can best be described as a set of three primary sister-city pairs in relatively concentrated development along the border with vast stretches of very sparsely developed rural lands in between and a number of smaller municipalities and towns farther away from the border but still within the 100-kilometer (km) border zone in both countries. A significant portion of this border region in Arizona is composed of the rural Tohono O'odham Nation, which shares the longest tribal border with Mexico along the entire binational boundary.

The Arizona-Sonora border region is arid desert, although significant variations in elevation lead to large differences in local climate and ecosystems. These differences have direct influences on air quality. Population and economic activity are increasing in this border area, although these increases are concentrated in the sister-city pairs of (from east to west) Douglas, Arizona-Agua Prieta, Sonora; Ambos Nogales (the name for the cities of Nogales, Arizona, and Nogales, Sonora); and Yuma, Arizona-San Luis Río Colorado (SLRC), Sonora. The Arizona-Sonora border is approximately 20% of the total length of the U.S.-Mexican border.

Differences and Parallels between Sister-City Pairs: An Overview

Douglas-Agua Prieta

Douglas and Agua Prieta are located in a relatively flat area on the eastern slope of what on the Arizona side is called the Sulphur Springs Valley. They are at an elevation of 4,000 feet, surrounded by several mountain ranges whose closest points are between 6 km and 50 km from the urbanized area (depending on the direction, and closest on the eastern side).

Summer temperatures in this arid region typically reach highs of slightly over 100ºF, while winter lows typically dip below freezing on several occasions every year. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Douglas to be 14.52 inches, based on data spanning the years 1948 to 2002 (Western Regional Climate Center No Date). As with much of southern Arizona and northern Sonora, the Douglas area receives this precipitation primarily during summer monsoons, secondarily during gentle winter rains, and rarely outside of these two seasons. The predominant wind direction is from southwest to northeast; because of the locally flat topography and the close proximity of the two communities, air quality in the two communities is quite similar.

Violations of the U.S. particulate matter (PM) standards in the late 1980s and early 1990s led to the federal designation of two small and localized nonattainment areas: Douglas and Paul Spur (a lime plant on the outskirts of Douglas). PM emission sources in the Douglas-Agua Prieta area are similar in nature, although not identical with respect to relative source contributions, to those in Ambos Nogales.

As with all sister-city pairs along the Arizona-Sonora border (Table 1), the Sonora side has a much larger population than the Arizona side. According to the Instituto Nacional de Estadística Geografía e Informática (INEGI), the population of Agua Prieta was 61,944 in 2000 (Gobierno del Estado de Sonora No Date-a), although local residents believe the actual population is closer to 110,000. The Arizona Department of Economic Security (ADES 2004) estimated the population of Douglas to be 16,740 in 2004.

Table 1. Population of Border Cities in Arizona and *Municipios* in Sonora

State	City/Municipio or Native Community	Population
Arizona	Douglas	16,740
	Nogales	21,375
	Yuma	86,070
	San Luis	21,180
	Somerton	8,855
	Naco	1,000
	Tohono O'odham Nation	24,000
Sonora	Agua Prieta	61,944
	Nogales	159,787
	San Luis Río Colorado	145,006
	Naco	7,000

Sources: Arizona Department of Economic Security and Instituto Nacional de Estadística Geografía Informática

Primary economic activities in the sister cities include customs brokerage services, the maquiladora sector, tourism, and local government and school employment. Although mining activities used to be locally important, the closure of several mines in both Arizona and Sonora has resulted in mining losing much of its importance for the local economy. A projected expansion of the power generation plant in Agua Prieta, however, will likely mean this sector of employment will gain increasing importance in coming years. The maquiladora sector has suffered a downturn recently, with the number of maquiladoras in Agua Prieta dropping significantly from a high of 34 in 2001 to 21 in 2003, and then to 20 in 2004 (Austin, et al. 2004).

In percentage terms, projected population growth rates in the two communities are moderately high. Because the communities are small to begin with, however, the projected future total populations are not expected to become very large when compared with Ambos Nogales or Yuma-SLRC. Because of its relatively small population, Agua Prieta has struggled to install basic infrastructure. As a result, unpaved roads are a dominant feature. Compared with Ambos Nogales, the relatively smaller size and projected growth rates of Douglas-Agua Prieta are likely due to the fact that Douglas and Agua Prieta are much farther away than Ambos Nogales from major cities located within the interiors of both states, such as Tucson and Phoenix in Arizona and Hermosillo in Sonora.

Ambos Nogales

Nogales, Arizona, at an elevation of 3,900 feet, has an ecosystem quite similar to that of Douglas-Agua Prieta. Summertime highs also typically peak at slightly over 100°F, and winter lows also dip below freezing several times each year. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Nogales to be 16.57 inches, based on data spanning the years 1948 to 1983 (Western Regional Climate Center No Date), making Ambos Nogales a slightly wetter area than Douglas-Agua Prieta. As with much of southern Arizona and northern Sonora, the Nogales area receives this precipitation primarily during summer monsoons, secondarily during gentle winter rains, and rarely outside of these two seasons. As in Douglas-Agua Prieta, the predominant wind direction is from southwest to northeast. However, certain characteristics of Ambos Nogales' geography are quite different from Douglas-Agua Prieta.

Unlike Douglas-Agua Prieta, Ambos Nogales is located within a narrow, north-south trending mountain valley. Peaks rise several hundred feet above the average elevation, and weather systems as well as stormwater runoff events can be more extreme than in Douglas-Agua Prieta because of this topography. Nevertheless, like Douglas-Agua Prieta, both communities in Ambos Nogales share many air quality characteristics. Due to violations of the air quality standards for PM in the late 1980s and early 1990s, the U.S. Environmental Protection Agency (EPA) designated the entire city of Nogales, Arizona, and a small portion of Santa Cruz County (primarily the southern half of unincorporated city Rio Rico, Arizona) as the Nogales Nonattainment Area. Primary sources of PM emissions in Ambos Nogales are unpaved roads and parking lots, vehicle emissions from passenger vehicles and heavy duty diesel vehicles, traffic congestion, soil erosion, and the residential burning of wood and garbage.

Ambos Nogales is the Arizona-Sonora sister-city pair with the largest populations and the highest levels of economic activity. According to INEGI, the population of Nogales, Sonora, in 2000 was 159,787 (Gobierno del Estado de Sonora No Date-b), although many local residents believe the actual population to be much higher—perhaps as great as 350,000. According to ADES, the population of Nogales, Arizona, was approximately 21,375 in 2004. It should be noted that there is a significant floating population in Nogales, Arizona. The U.S. Bureau of Customs and Border Protection estimates that approximately 40,000 people cross the border from Nogales, Sonora, into Nogales, Arizona, legally on a daily basis, and then return to Nogales, Sonora, on the same day.

The most important economic activities in Ambos Nogales are in the produce, maquiladora, customs brokers, and tourism sectors. It has been estimated that up to 70% of all fresh produce consumed in the entire United States and Canada during winter months is grown in Mexico and imported through Nogales. As in Agua Prieta, the maquiladora sector has suffered a downturn in recent years in

Nogales, Sonora, going from a high of 109 maquiladoras in 2001 to a low of 73 in 2002. Unlike Agua Prieta, however, Nogales has started to see some recovery in this sector, with 81 maquiladoras in operation in 2004 (Austin, et al. 2004). Additional significant areas of economic activity include the government and education sectors.

Yuma-San Luis Río Colorado

The Yuma-SLRC region comprises several different communities, not all of which border continuously with each other. They are commonly separated by agricultural areas. Yuma, Arizona, at an elevation of only about 150 feet above sea level, has an ecosystem quite different from Douglas-Agua Prieta or Ambos Nogales. Summertime highs typically peak at 110°F, and winter lows are typically around 45°F to 50°F, with freezes rarely occurring. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Yuma to be 3.33 inches, based on data spanning the years 1893 to 1974 (Western Regional Climate Center No Date), making Yuma considerably drier than Ambos Nogales and Douglas-Agua Prieta. Unlike Ambos Nogales and Douglas-Agua Prieta, the Yuma-SLRC area receives its precipitation almost exclusively during summer monsoons.

The Yuma-SLRC region is located in a very large, relatively flat valley, surrounded by low mountain ranges (or high hills) located a significant distance from the population centers. Although air quality in the border sister-city pair of San Luis, Arizona, and San Luis Río Colorado, Sonora, is quite similar due to the two cities' proximity, air quality in other communities in this region likely varies somewhat, although the communities are still mutually influenced. The nature and reasons for this variability have yet to be determined. Due to violations of the air quality standards for PM in the late 1980s and early 1990s, EPA designated the Yuma Nonattainment Area, which includes a portion of western Yuma County with the cities of Yuma and Somerton and portions of the Yuma Proving Ground. Primary sources of PM emissions in the Yuma Nonattainment Area are, in descending order of contribution, windblown dust, unpaved roads, road construction, agricultural tilling, re-entrained dust from paved road construction, and agricultural and prescribed burning. Emissions from brick kilns are also a concern in the area closest to the international border.

According to INEGI, the population of SLRC in 2000 was 145,006 (Gobierno del Estado de Sonora No Date-c), although many local residents believe the actual population to be somewhat higher—perhaps as high as 180,000. According to ADES, the population of Yuma was 86,070 in 2004, and two nearby communities (San Luis and Somerton) had an additional 30,035 people (Table 1).

Thus, although the adjacent sister-city communities of San Luis and SLRC have a similar population balance to those of Ambos Nogales and Douglas-Agua Prieta, the total population on the Arizona side of the entire Yuma-SLRC region is much larger than in the other regions. It should be noted that there is daily and seasonal binational population movement in the Yuma area, as agricultural workers living in SLRC travel to work legally in the agricultural areas of Yuma County. The degree to which this day-time influx influences the total population, however, is not known to the authors.

The most important economic activities in Yuma-SLRC are in the agricultural, customs brokers, maquiladora, tourism, and government/school sectors. Presumably, the maquiladora sector has suffered a downturn in recent years in SLRC similar to that seen in Nogales, Sonora, and Agua Prieta. SLRC had 42 maquiladoras in 2001, but as of 2002, *Twin Plant News* (the source of the data reported in Austin, et al. 2004) no longer separated the numbers of maquiladoras in SLRC from totals for the rest of Sonora, outside of Nogales and Agua Prieta.

Other Parts of the Arizona-Sonora Border

Most of this chapter will focus on the three areas described above. There are, however, several more geographical areas between those three along the Arizona-Sonora border that deserve mention either with respect to air quality or to give a better sense of the entire region. Moving from east to west, the first of these is the sister-city pair of Ambos Naco—the unincorporated community of Naco, Arizona, and the small municipality of Naco, Sonora, which are located approximately 20 miles west of Douglas-Agua Prieta and a 15-minute drive south of Bisbee, Arizona. The population of Naco, Arizona, is approximately 1,000 and the population of Naco, Sonora, is about 7,000.

Although PM has not been deemed a problem in Ambos Naco at levels warranting the designation of a nonattainment area, the area was challenged for many years by sporadic fires at the municipal dump in Naco, Sonora. The smoke from these fires was occasionally thick enough to cause the Bureau of Customs and Border Protection to close down the port of entry, an action that is quite disruptive to the local community as well as travelers throughout the surrounding region. After a few years of responding to these events and discussing them with officials and residents on both sides of the border, the Arizona Department of Environmental Quality (ADEQ) determined that many of the fires were likely caused by the disposal of ashes from residential cooking and heating that were not completely extinguished. Once in the dump, these ashes were causing combustible materials also present in the dump to catch fire. During the winter of 2003–2004, ADEQ distributed copies of a simple flier encouraging residents to ensure their ashes were completely extinguished before disposing of them in the dump. Municipal authorities in Naco, Sonora, distributed copies to all residents through door-to-door visits. Since that outreach was conducted there have not been any more fires at the dump. In the meantime, efforts are underway to upgrade waste management facilities in Naco, Sonora.

The Coronado National Forest, comprising five ranger districts, covers 1.78 million acres of land, mostly in southeastern Arizona but with a small portion in southwestern New Mexico. Two major portions of the Coronado National Forest are located directly along the Arizona-Sonora border, one between Naco-Sierra Vista and Nogales and the other to the west of Nogales. As with other forest areas throughout the state of Arizona, these areas are susceptible to wildfires, and controlled burns have occasionally been used in these areas with the hope of preventing larger, uncontrolled wildfires.

The Chiricahua Wilderness Area and the Chiricahua National Monument Wilderness Area are designated Class I Areas under the Clean Air Act. Ozone is regularly monitored at a station located at the Chiricahua National Monument. Although the National Monument is outside the 100-km border zone, it is close enough that air quality there could reasonably be used as a background reference site in comparison to air quality in Douglas-Agua Prieta and Ambos Nogales, were ozone to be monitored in those communities in the future.

Continuing toward the west, the next area of significant importance along the Arizona-Sonora border is the Tohono O'odham Nation (the formal name on the U.S. side), with a U.S. population of approximately 24,000 and another approximately 1,400 members in Mexico. Comprising a total area in Arizona about the same size as the state of Connecticut, the Tohono O'odham Nation has a 75-mile border with Sonora. A substantial portion of the nation is located within the 100-km border region and there are a number of Tohono O'odham communities in Sonora, as the nation's traditional lands are bisected by the international boundary. Although no air quality monitoring has been conducted within the Tohono O'odham Nation, tribal leaders have raised concerns about the possible air quality impacts of wood burning, garbage burning, unpaved roads, and agricultural practices.

Bordering the Tohono O'odham Nation on the west, the Organ Pipe Cactus National Monument also shares a long (approximately 30 miles) border with Mexico. ADEQ maintains a PM_{10} (particulate matter measuring 10 microns or less in diameter) sampler at the monument, as well as a nephelometer measuring visibility.

Continuing west, the Cabeza Prieta National Wildlife Refuge borders on both Sonora and the Organ Pipe Cactus National Monument. Next, the Barry M. Goldwater Air Force Range borders both Sonora and the Cabeza Prieta National Wildlife Refuge.

In the stretch of the border region from the eastern edge of the Arizona portion of the Coronado National Forest to the western edge of the Barry M. Goldwater Air Force Range (located about 15 miles east of San Luis, Arizona)—representing 280 miles of the total Arizona-Sonora border, which measures 360 miles—there is very little non-federal, non-tribal land.

Contrasts with Other Regions

The previous section demonstrates that the Arizona-Sonora border region may be characterized as almost entirely rural, with three concentrated areas of urban development where most of the air quality concerns arise. Although on the surface this general characterization (urban areas of concern separated by large rural areas) may seem similar to the characterizations of other regions along the U.S.-Mexican border, there are some important differences. Also, while these three areas share some characteristics in common, they also have several differences among them that will become clearer in later sections of this chapter.

The populations, levels of economic activity, and total quantities of inventoried emissions from various sources in other parts of the U.S.-Mexican border region are generally significantly larger than those found along the Arizona-Sonora border. This difference of scale has several consequences, many of which will be explored later in this chapter. For example, the financial resources made available to address air quality issues along the Arizona-Sonora border are considerably less than in other regions. The institutional capacity to address air quality issues is also less, whether measured by the size of local governments, the number of colleges and universities, the number of non-governmental and community-based organizations, or the number of businesses and their ability to benefit directly from participation in air quality improvement activities. Because federal air environmental activities along the U.S.-Mexican border have focused on the larger metropolitan areas such as San Diego, California-Tijuana, Baja California, and Paso del Norte (El Paso, Texas; Doña Ana County, New Mexico; and Ciudad Juárez, Chihuahua), air quality issues important to Arizona-Sonora communities may struggle to receive national-level policy attention if they are not accorded the same level of importance as other regions of the border.

Nevertheless, working in the Arizona-Sonora border region may also have its advantages. The second type of difference between the Arizona-Sonora border region and other parts of the U.S.-Mexican border relates to the nature of binational cooperative efforts. At the formal level of state-to-state cooperation—an important aspect of the model set up by Border 2012—Arizona and Sonora have a decades-long history of collaborative efforts. The Paso del Norte region, with 10 years of collaboration on air quality, is the only other area that approaches the maturity of the Arizona-Sonora relationship.

Much of this success has been accomplished through the Arizona-Mexico Commission and its sister organization, the Comisión Sonora-Arizona. The Environment Committees of these organizations have adopted many recommendations and action items over the years relating to air quality along the Arizona-Sonora border. It is often the approval of these commissions, which are chaired by the governor of each state, that allows binational cooperation on air quality (and other environmental matters) to proceed without the need for the protracted negotiations involved in establishing federal treaties. This state-to-state cooperation has allowed ADEQ, with support and approval from the Secretaría de Infraestructura Urbana y Ecología (SIUE), to carry out important efforts like conducting outreach in Sonora, working directly with Sonoran municipalities to establish air quality monitoring stations, and providing direct technical assistance to Sonoran municipalities in obtaining Border Environment Cooperation Commission (BECC) certification of air quality projects.

As a result of the direct role of the two state governments in border air quality efforts, it may be easier in this region to transfer successes and lessons learned from one community to another. In addition, the much smaller total population and economic growth pressures in a community like Douglas-Agua Prieta, compared to other areas, may make it easier for these cities to succeed in the cooperative air quality improvement efforts described below.

In short, the Arizona-Sonora border region is a rural region with small urbanized areas trying to succeed in a binational program of much larger, more urbanized scale. This contrast has both its challenges and its advantages.

Background on Air Quality

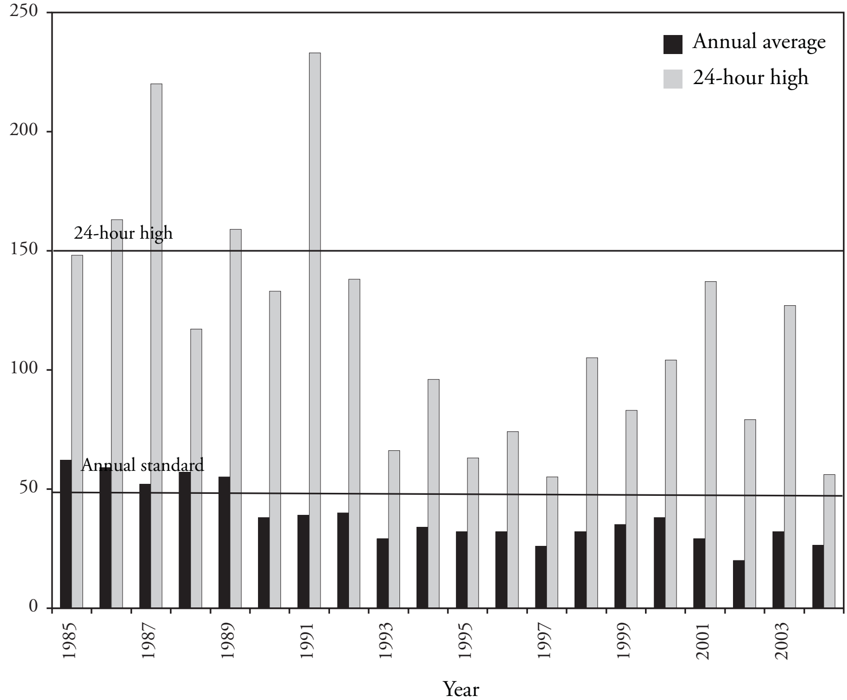
Monitoring Results and Compliance Status

This section summaries the results of ambient air quality monitoring in the Arizona-Sonora region and shows how those results relate to the National Ambient Air Quality Standards (NAAQS) in the United States and the similar set of Normas Oficiales Mexicanas (NOM) established by Mexico. These standards are listed in Table A near the beginning of this volume. As well, Table B explains the criteria applied to the U.S. standards in order to determine attainment or nonattainment in specific geographic areas in the United States.

Douglas-Agua Prieta

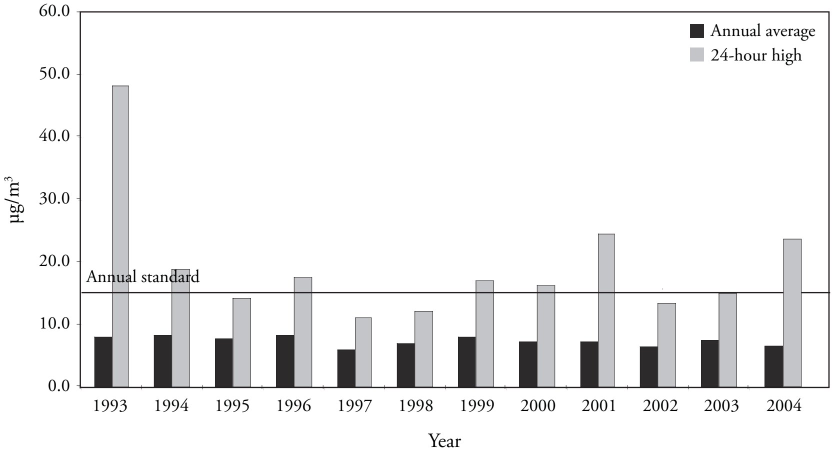
In Douglas, monitoring of PM_{10} concentrations began in 1985 and monitoring of $PM_{2.5}$ (PM $_{2.5}$ microns or less in diameter) began in 1993. In Agua Prieta, monitoring of both PM_{10} and $PM_{2.5}$ began in 1999. Figures 1 and 2 show data trends for Douglas for PM_{10} and $PM_{2.5,}$ respectively. Similarly, Figures 3 and 4 show data trends for PM_{10} and $PM_{2.5}$ in Agua Prieta. In the figures for $PM_{2.5,}$ the maximum 24-hour average is shown. The federal standard is expressed as the 98th percentile value, but because the sampling frequency is every sixth day, yielding about 60 samples per year, the maximum value and the 98th percentile value are the same.

Figure 1. Annual Average and Annual 24-Hour High for PM_{10} in Douglas, Arizona, 1993–2003



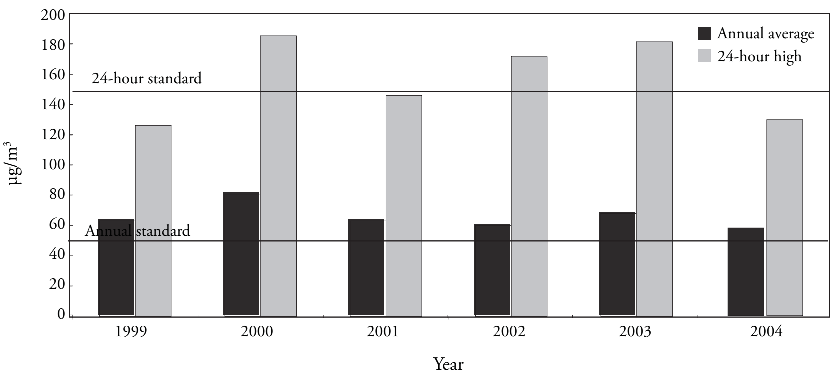
Source: Arizona Department of Environmental Quality

Figure 2. Annual Average and Annual 24-Hour High for $PM_{2.5}$ in Douglas, Arizona, 1993–2003



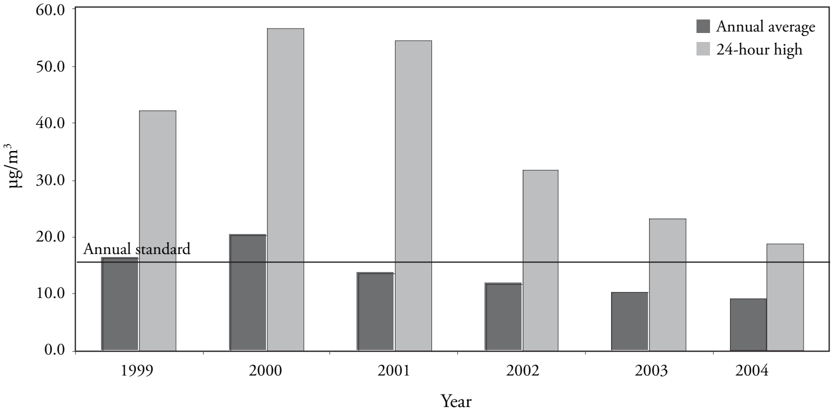
Source: Arizona Department of Environmental Quality

Figure 3. Annual Average and Annual 24-Hour High for PM_{10} in Agua Prieta, Sonora, 1999–2003



Source: Arizona Department of Environmental Quality

Figure 4. Annual Average and Annual 24-Hour High for $PM_{2.5}$ in Agua Prieta, Sonora, 1999–2003



Source: Arizona Department of Environmental Quality

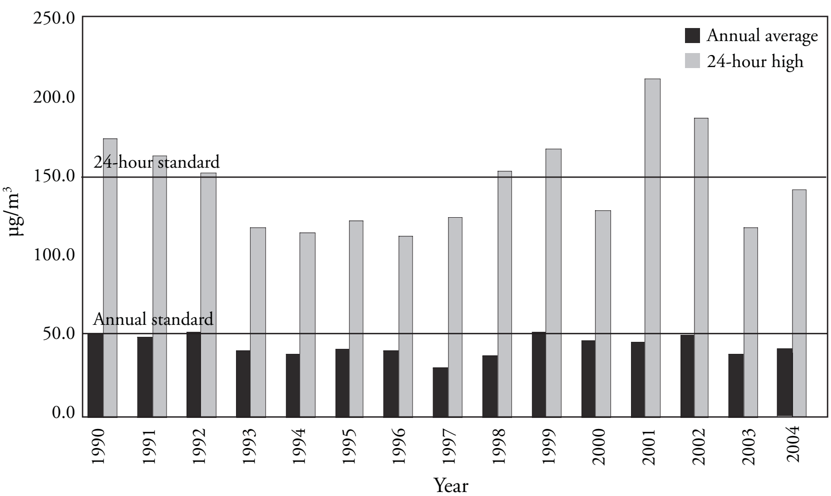
These graphs show several interesting things. First, Douglas violated the annual standard from 1985 through 1989 and the 24-hour standard in four of the seven years from 1985 through 1991. Since that time, Douglas has consistently met the U.S. air quality standards. Annual averages for concentrations of both PM_{10} and $PM_{2.5}$ have remained relatively constant since the early 1990s. The highest 24-hour reading for $PM_{2.5}$ has also remained relatively constant during this period, except for two outlying values recorded in 1993 and 2001—both of which were well within the compliance range. While the highest 24-hour readings for PM_{10} may show a somewhat upward trend during the monitoring period, these values are still within the compliance range (it is impossible to explain this apparent upward trend without conducting a significantly more detailed evaluation of all data collected).

The data for Agua Prieta show PM_{10} concentrations above the applicable Mexican air quality standards (Mexican Allowable Limits) almost every year, with both the annual average and the highest 24-hour reading remaining relatively constant during the monitoring period. Mexico did not have $PM_{2.5}$ standards when this analysis was originally prepared (such standards were established in September 2005 and are included in Table A at the beginning of this monograph), but the $PM_{2.5}$ data show Agua Prieta would have complied with the U.S. 24-hour standard during the entire monitoring period. Although $PM_{2.5}$ annual average values would have violated the U.S. standard at the beginning of this monitoring period, the annual averages in more recent years would comply with the U.S. standard. Both annual average and 24-hour values show a downward trend in Agua Prieta.

Ambos Nogales

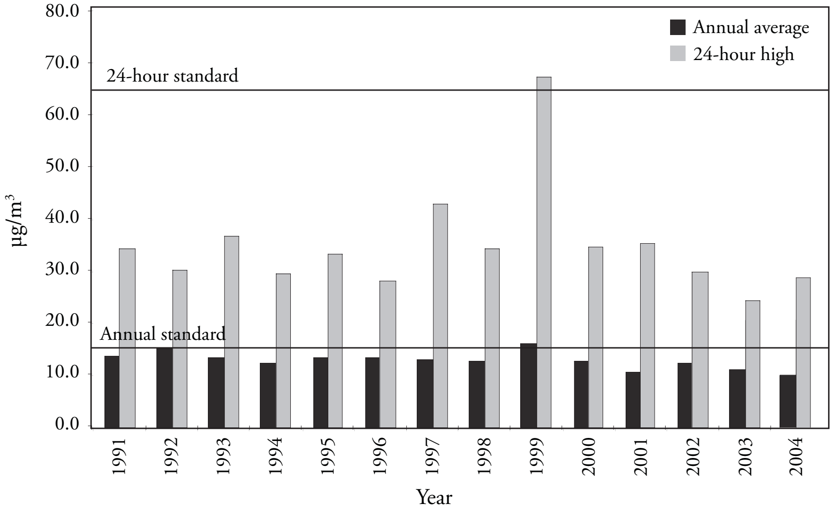
PM data have been collected in Nogales, Arizona, and Nogales, Sonora, since 1990 and 1995, respectively. Figures 5 and 6 show data trends for Nogales, Arizona, for PM_{10} and $PM_{2.5,}$ respectively. Figures 7 and 8 show data trends for PM_{10} and $PM_{2.5}$ in Nogales, Sonora.

Figure 5. Annual Average and Annual 24-Hour High for PM_{10} in Nogales, Arizona, 1990–2003



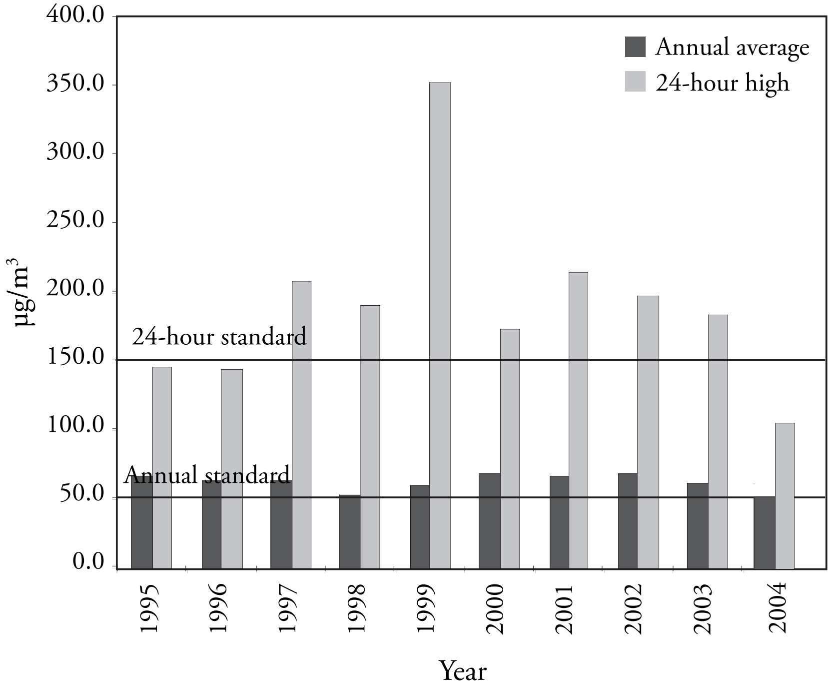
Source: Arizona Department of Environmental Quality

Figure 6. Annual Average and Annual 24-Hour High for $PM_{2.5}$ in Nogales, Arizona, 1991–2003



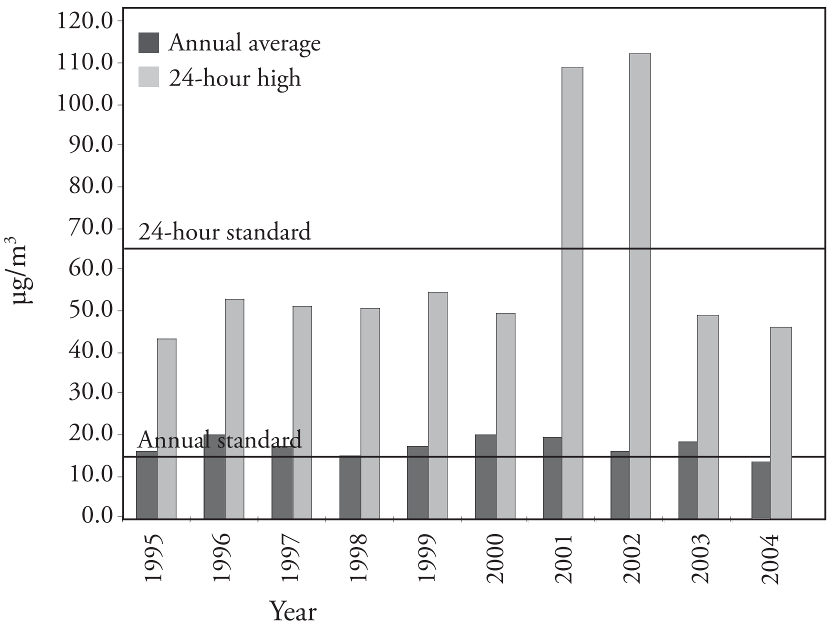
Source: Arizona Department of Environmental Quality

Figure 7. Annual Average and Annual 24-Hour High for PM_{10} in Nogales, Sonora, 1995–2003



Source: Arizona Department of Environmental Quality

Figure 8. Annual Average and Annual 24-Hour High for $PM_{2.5}$ in Nogales, Sonora, 1995–2003



Source: Arizona Department of Environmental Quality

In reviewing the data in these graphs, the first point to note is that Nogales, Arizona, has not violated the annual PM_{10} standard since the early 1990s. However, PM_{10} annual average levels have shown an upward trend since 1996, with the exception of 2000 and 2003. PM_{10} annual averages in a few individual years exceeded the standard, but compliance is determined by three-year running averages and Nogales has never been in violation, although in one period it came very close. On the other hand, the 24-hour PM_{10} standard has been violated consistently since 1998. Although there is variation in the data, the yearly maximum 24-hour PM_{10} concentrations increased from 1996 to 2001, and then began to decrease.

$PM_{2.5}$ levels in Nogales, Arizona, have generally complied with the annual and 24-hour standards, although there have been occasional exceedances. Both annual average and 24-hour levels have consistently fluctuated within a steady range, although the 98th percentile 24-hour level for 1999 was well above all other years, as was the annual average for 2003.

With regard to PM_{10} concentrations in Nogales, Sonora, both the 24-hour concentrations and the annual averages are generally slightly higher than those in Nogales, Arizona, with the Mexican Allowable Limits regularly being violated.

Over time, these levels have fluctuated within a fairly constant range. $PM_{2.5}$ levels in Nogales, Sonora, have also generally fluctuated within a fairly constant range, and the annual averages would consistently violate the U.S. standard, although the 98th percentile 24-hour values would generally comply with the U.S. standard. The 98th percentile 24-hour values for 2001 and 2002 show a notable exception, significantly exceeding the U.S. standard.

There are various possible explanations for these data trends. First, in the mid-1990s both the annual average and 24-hour PM_{10} concentrations were down in Nogales, Arizona, compared to earlier years when violations led to the designation of the nonattainment area. This reduction may be a result of actions taken on the basis of the State Implementation Plan (SIP) for the Nogales Nonattainment Area, adopted in 1993. They may also reflect the closure of the old landfill in Nogales, Sonora, and the cessation of garbage-burning activities that used to occur there regularly. However, once these actions had their effect, perhaps the continuing growth in the population of Ambos Nogales once again contributed to increased emissions levels from more unpaved roads, more cars, more soil erosion, and more wood and garbage burning. In addition, crossborder commerce has also grown, which leads to more truck and passenger vehicle traffic. Finally, most of the PM_{10} 24-hour highest values have occurred during the winter months, which may reflect a combination of a higher incidence of wood-burning for home heating and atmospheric inversion layers that trap emissions in the Ambos Nogales valley.

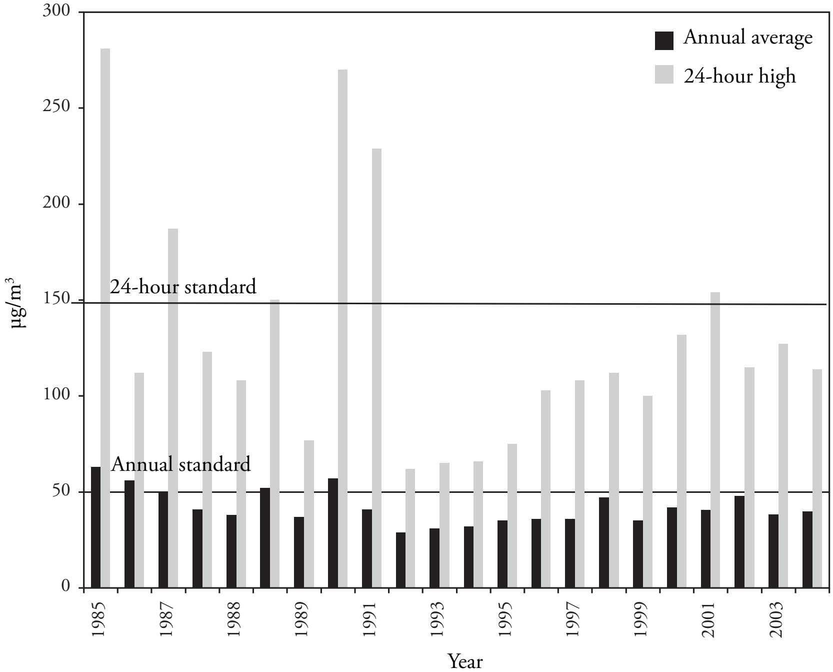
For several reasons, PM is the only category under NAAQS regularly monitored in Ambos Nogales. A binational ADEQ-Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) study (published in 1999) monitored lead concentrations but did not find any problem. Sulfur dioxide is presumed not to be an issue because there are no smelters or other important sources of sulfur dioxide emissions in Ambos Nogales. The other criteria pollutants—ozone, nitrogen oxides (NO_x), and carbon monoxide—have not been monitored in Ambos Nogales for more than nine years, and no local monitoring stations for any of these pollutants exist. ADEQ is currently working to install a monitor capable of measuring these three pollutants in Ambos Nogales' air to make a preliminary determination of whether there may potentially be a nonattainment issue and whether more detailed monitoring is warranted.

Yuma-SLRC

Through 2005, air pollution monitoring efforts in this sister-city area were limited to Yuma County. Long-term trends in that county have been assessed for both particulates and ozone. The binational air toxics monitoring program began in February 2006 with the installation of sites in Yuma and SLRC. This section presents the Yuma ambient air quality record.

Monitoring for PM_{10} began in Yuma in 1985 and has continued through the present. The monitoring data presented in Figure 9 show exceedances of both the annual and 24-hour standards occurred through the early 1990s, but since then the standards have been met. On August 18, 2002, a 24-hour average concentration of 170 micrograms per cubic meter ($\mu g/m^3$) was recorded. Subsequent analysis showed the extremely windy and dry conditions of that date qualified it as a "natural exceptional event." Through a Natural Events Action Plan (NEAP), Somerton, the City of Yuma, and Yuma County have agreed to apply the Best Available Control Measures (BACM) to the contributing PM_{10} emission sources in return for having the concentration removed from the compliance record.

Figure 9. Annual Average and Annual 24-Hour High for PM_{10} in Yuma, Arizona, 1985–2004

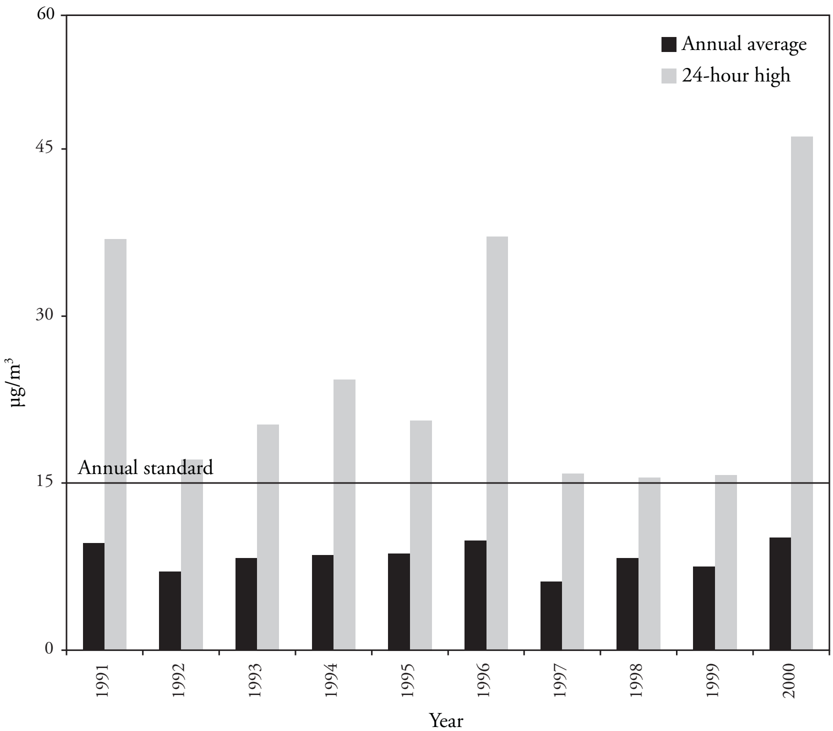


Source: Arizona Department of Environmental Quality

The overall PM_{10} trends depict elevated, above-standard concentrations in the mid-1980s and early 1990s, followed by a long period of uninterrupted compliance with the standards. Because of the PM_{10} violations in the 1980s, the western area of Yuma County was designated a moderate PM_{10} nonattainment area by the 1990 Clean Air Act Amendments. ADEQ completed a SIP for the Yuma Moderate PM_{10} Nonattainment Area in 1991 and updated the plan in 1994. As a result of several years of measured attainment with the air quality standards for PM_{10}, ADEQ began working with the stakeholders in July 2001 to develop a request to EPA to redesignate Yuma from non-attainment to attainment. This request requires a "maintenance plan" that demonstrates that the control measures in effect will assure compliance with the standards for at least 10 years. It also requires the most recent three years of monitoring data meet the standards.

$PM_{2.5}$ concentrations, monitored with dichotomous samplers throughout the 1990s (Figure 10), were within the ambient air quality standards in Yuma. Only three 24-hour average samples exceeded 30 μg/m^3 and none exceeded 50 μg/m^3, within the standard of 65 μg/m^3. Annual averages ranged from 6 μg/m^3 to 10 μg/m^3, well within the standard of 15 μg/m^3.

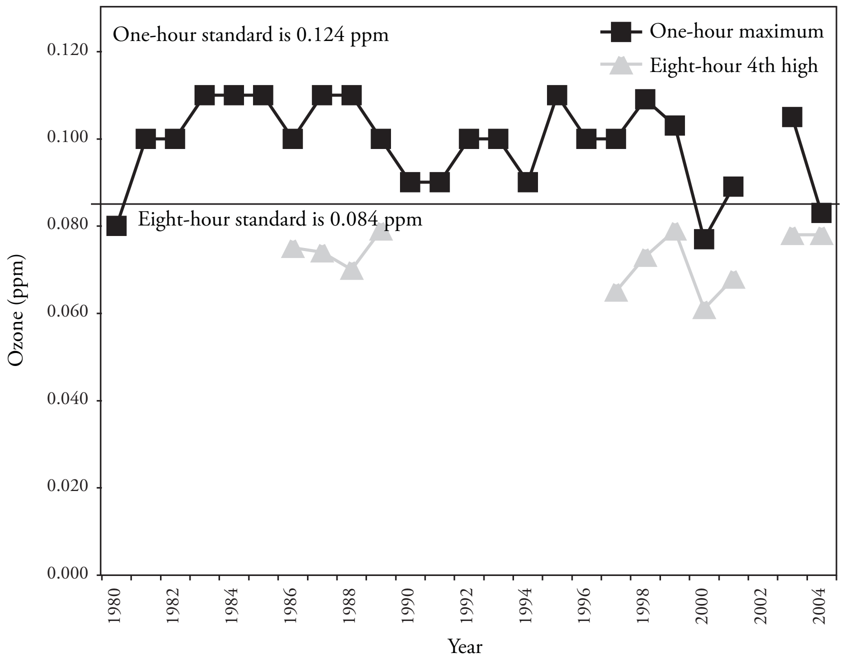
Figure 10. Annual Average and Annual 24-Hour High for PM_{10} in Yuma, Arizona, 1991–2000



Source: Arizona Department of Environmental Quality

Monitoring for ozone began in Yuma in 1980. Maximum one-hour and the fourth-highest eight-hour concentrations have been well within the ambient standards. Figure 11 shows that these values have fluctuated somewhat but have remained steady with neither an upward nor downward trend in the 25-year period. In addition to ozone, monitoring in Yuma began for NO_x, an ozone precursor, in 2003.

Figure 11. Maximum One-hour and Fourth-Highest Eight-hour Concentrations of Ozone in Yuma, Arizona, 1980–2004



Source: Arizona Department of Environmental Quality

Binational Study Methods and Results

Binational air quality monitoring and modeling efforts along the Arizona-Sonora border began in 1995 with the installation of three monitoring stations in Ambos Nogales. These three new sites had been preceded by the first monitoring site at the Nogales, Arizona, post office in 1990. Together, these four stations comprised a binational network that was created to address air quality concerns through a five-year, comprehensive study funded by EPA. The Ambos Nogales study was the first of its kind anywhere along the U.S.-Mexican border and set the stage for similar cooperative projects to follow in other border sister cities.

A second binational air quality study was started in Douglas, Arizona, and Agua Prieta, Sonora, in 1999, drawing from the experience gathered through the Ambos Nogales effort. Once the data collection phase of each of these binational studies was completed, local air quality monitoring efforts were scaled back to focus on PM, with one monitoring station in each of the four communities. These ongoing monitoring efforts allow the evaluations of trends over time, as discussed above. A third binational study, the largest of its kind anywhere along the U.S.-Mexican border, is in its initial stages in the Yuma-SLRC region. This section describes the status and results (where available) of these binational studies.

Study Phases

The Ambos Nogales study was prompted by community concerns about the high incidence of certain ailments and illnesses (such as asthma, lupus, and multiple myeloma) in the sister communities. These health conditions were thought to be attributable, at least in part, to poor air quality. As mentioned above, the Ambos Nogales study began with one year of binational air quality monitoring at six stations (three on each side of the border) that included meteorological parameters (wind speed and wind direction), PM_{10} and $PM_{2.5}$, aldehydes, volatile organic compounds (VOCs, including several hazardous air pollutants, or HAPs, such as aldehydes), and semi-volatile organic compounds (SVOCs). The study area was approximately 5 km from east to west and 10 km from north to south. In addition to the sampling/monitoring effort, the Ambos Nogales project included the development of an air emissions inventory, atmospheric simulation models, and a human health risk assessment for both sides of the border. The study was published in 1999 (ADEQ 1999).

The Douglas-Agua Prieta study began with air quality monitoring at four stations (two on each side of the border), covering a study area of approximately 32 km from east to west and 40 km from north to south. In addition to the components and parameters used in the Ambos Nogales study, the Douglas-Agua Prieta effort included carbon monoxide and NO_x monitoring, the use of a wind profiler to better understand wind patterns at the different levels of the atmosphere, time-lapse photography, and the use of portable PM_{10} monitors, among other improvements. An emissions inventory of the Douglas-Agua Prieta area was completed in summer 2002. Since then, efforts have focused on air quality modeling in order to establish the exposures that local residents likely experience; this modeling is based on data gathered during the air quality monitoring and emissions inventory phases. As in the case of Ambos Nogales, this binational study will conclude with a public health risk assessment to determine the community impacts resulting from the modeled likely exposures.

As mentioned above, the Yuma-SLRC binational study, often referred to as the Western Arizona Sonora Border Air Quality Study, will be the largest of its kind ever undertaken along the U.S.-Mexican border. The study area is approximately 60 km from north to south and 80 km from east to west. It covers parts of three states (Arizona, Sonora, and Baja California), several towns and municipalities, and three Native American tribal nations. As the study develops, there may be a need to explore the possible influence of emissions from another major binational metropolitan area—Mexicali-Calexico—on air quality in the Yuma-SLRC area. Clearly, this study will require unprecedented levels of coordination. At this time, meteorological data is being gathered at several locations on both sides of the border to determine the more stable locations to collect air samples. Future study phases will likely follow the pattern established in the Ambos Nogales and Douglas-Agua Prieta binational studies, including air quality monitoring, the development of an emissions inventory, and a public health risk assessment.

Primary Contaminant Sources

Prior to the commencement of the Ambos Nogales binational study, the old municipal dump in Nogales, Sonora, was seen by community residents as the root of their air quality-related problems. Open burning would occur regularly at the dump, largely driven by cottage-industry waste recovery efforts such as burning the plastic coating off copper wire in order to recover the valuable copper. The municipal dump was closed in 1995 and replaced with a modern landfill in the southern end of the city, which has not presented any garbage burning-related problems since it was opened.

The Ambos Nogales binational study found that PM_{10} is the primary health risk factor in the Ambos Nogales air. Unpaved road dust is the main source, and approximately 85% of the PM_{10} in Nogales, Arizona, was found to originate in Nogales, Sonora. In addition, it was determined that vehicular emissions are the leading source of HAPs.

Based on this study and knowledge of local conditions, local efforts to improve air quality now focus on five primary PM_{10} emissions sources:

- Residential emissions (from the burning of wood and garbage at or near people's homes)
- Soil erosion (which deposits on paved and unpaved roads, raising their emissions levels)
- Unpaved traffic areas (roads and parking lots)
- Traffic congestion (especially at the ports of entry, in relation to the train route, and at under-designed intersections)
- Vehicle emissions (from passenger vehicles as well as commercial trucks), which are also a source of HAPs

The phases of the Douglas-Agua Prieta study completed to date show emissions from unpaved roads are the largest contributors of PM. Wind erosion of crustal materials from such surfaces as vacant lots and other disturbed areas is also a significant source of PM in the area. This study also paid special attention to a few emissions sources perceived as possible problems by local residents, such as brick kilns and tire dragging (which the Border Patrol conducts to smooth the dirt on unpaved roads near the border as part of its effort to track undocumented entry into the United States). The study found emissions from burning fuels at brick kilns do indeed have a measurable effect on local air quality. The tire dragging accounted for only 0.8% of the on-road mobile PM_{10} emissions. On-road mobile sources account for approximately 91% of the overall HAP emissions and 87% of the total carbon monoxide emissions in the study domain. This source category is also the largest contributor of NO_x emissions in the study domain.

Oxides of sulfur (SO_x) in this area are predominantly emitted by the Mexicana de Cobre lime plant in Agua Prieta and the lime plant located in Paul Spur, west of Douglas. The former plant has been in continual operation in the last 20 years, while the latter has been shut down for several years. SO_x has not been measured in Douglas since the close of the Phelps-Dodge smelter in 1987.

An additional source of SO_x emissions is the Union Fenosa power plant south of Agua Prieta, which began operations in 2003. The Comisión Federal de Electricidad (Mexican Federal Electricity Commission) recently announced that this power plant will be expanded from 350 megawatts (MW) to 1,450 MW by 2008, with an increase in SO_x emissions from 33 tons to 133 tons per year. The 1,100 MW of additional capacity will comprise a gas-fired combined cycle plant. Also, a 30-MW array of solar photovoltaic panels will be installed nearby on 50 hectares of land.

As neither the air quality monitoring for criteria pollutants and HAPs nor the emissions inventory have commenced for the Yuma-SLRC binational study, it is premature to draw firm conclusions about the primary emission sources impacting air quality in this area. In general, however, it is expected that unpaved roads, vehicle emissions, traffic congestion, soil erosion, and residential garbage burning will likely be shown to play important roles, as they do in Ambos Nogales and Douglas-Agua Prieta.

In addition, several specific issues have been identified for attention in Yuma-SLRC as the binational study progresses. These include agricultural burns, brick kilns, agricultural tilling practices, garbage burning at the municipal dump, unpaved roads, and the role SLRC plays in connecting commercial traffic from Baja California to the rest of Mexico. Some preliminary information about these sources is available. Approximately 98% of all agricultural land in the area is planted in wheat; these fields are typically burned from June through September. The remaining 2% is planted almost entirely in asparagus, and these fields are typically burned during March and April.

Combustion at brick kilns and the municipal dump in SLRC generate problematic emissions. There are an estimated 130 brick kilns in SLRC and another 100 in the surrounding areas. Garbage burning at the dump still occurs, unlike in Douglas-Agua Prieta and Ambos Nogales, although the frequency and size of these burns are unknown. Additionally, it is estimated that approximately 83% of all roads in SLRC are unpaved.

Finally, there is a great deal of both domestic and crossborder heavy-duty diesel commercial truck traffic through the Yuma-SLRC area. This traffic occurs partly because Mexican Route 2 provides the only land transportation between Baja California and the rest of Mexico. Another important factor is truckers importing goods to the United States in the Yuma area have various choices of ports of entry—those in San Luis, and those en route to and in Calexico-Mexicali, which is not far away. It is unclear how these choices affect the number of trucks waiting in line to cross the border in San Luis.

Another factor that will need to be taken into account during the binational study and that differentiates Yuma-SLRC from Ambos Nogales and Douglas-Agua Prieta is the fact that soils throughout the Yuma-SLRC area appear to be much finer grained than soils in other parts of the Arizona-Sonora border. This difference is likely due to the long-term geological influence of the Colorado River.

Health Impacts

Ambos Nogales Health Risk Assessment

In the binational study for Ambos Nogales (ADEQ 1999), adverse health effects were evaluated for two types of "receptor" individuals that were selected as representative examples of the general population on each side of the border. The first type, a reasonable maximal exposure (RME) receptor, is a designation for people who have relatively high exposures to the studied HAPs—essentially a "worst case" scenario. The RME applies to individuals who live or work near major sources of pollution and who may, therefore, be exposed to higher concentrations than the general population. Secondly, a central tendency case (CTC) receptor identifies people who have average exposures. Studying these two cases provides a realistic range of exposures and the associated human health risks.

Risks due to PM_{10} exposure were estimated by using human health statistics derived from epidemiological studies and applying them to the concentrations to which the RME and CTC receptors are expected to be exposed. The RME and CTC exposure areas are the same for HAPs and PM_{10}. The percentage increase in cases of health problems on an average daily basis related to PM_{10} pollution was estimated. In addition, the expected increase in numbers of premature respiratory and cardiovascular deaths among elderly people who already have lung or heart problems was estimated. This is the percentage increase in the number of deaths per year per thousand people. Both of these kinds of percentage increases in health effects are those percentages associated with an increase in PM_{10} concentrations of 10 $\mu g/m^3$. These estimates are provided in Table 2.

Table 2. Estimated Percentage Increase in Health Effect Cases and Estimated Increase in Absolute Numbers of Premature Deaths in Ambos Nogales Caused by Each Increment of 10 µg/m^3 of PM_{10}

Health Effect	Percentage Increase in Incidence, by Location and Exposure Scenario			
	Nogales, Arizona		Nogales, Sonora	
	CTC[1]	RME[2]	CTC[1]	RME[2]
Hospital admissions	2	3	2	4
Asthma episodes	8	13	8	14
Lower respiratory illness	8	13	8	14
Coughs	3	5	3	6
Premature respiratory deaths	2	3	16	28
Premature cardiovascular deaths	3	5	28	44

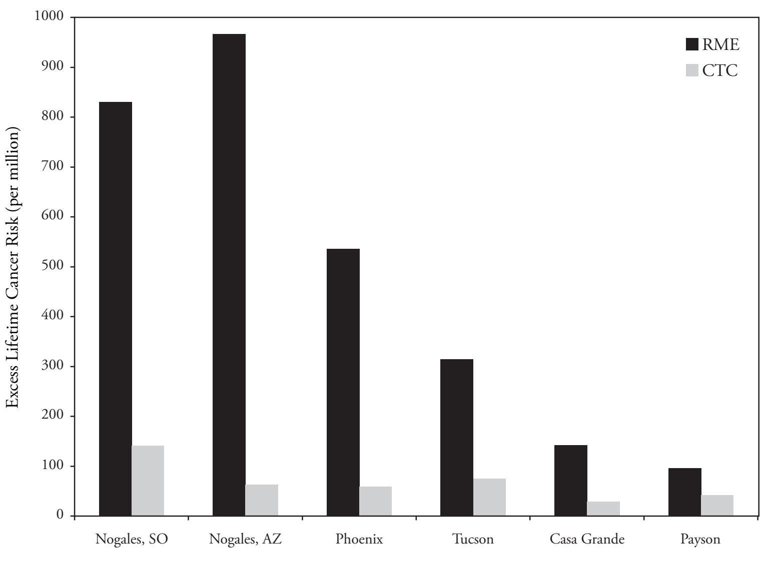
[1] CTC = Central tendency case (individuals with average exposure to the studied hazardous air pollutants)
[2] RME = Reasonal maximal exposure (individuals with high exposure to the studied hazardous air pollutants)
Source: Arizona Department of Environmental Quality

The increased percentages of health problem cases resulting from PM were generally the same in Nogales, Arizona, and Nogales, Sonora, because residents of both communities are exposed to similar concentrations of PM. The absolute numbers of premature deaths that may be attributed to PM exposure are higher in Nogales, Sonora, because the population is larger—by as much as tenfold or more—than in Nogales, Arizona.

These health risks from PM_{10}, as well as the risks from HAPs, can be put into the context of the health risks determined in the Arizona HAPs project for four Arizona cities and towns. Results from the Arizona HAPs study and the Ambos Nogales study show risks from PM_{10} exposure in Ambos Nogales were generally somewhat lower than in Phoenix, while somewhat higher than in Tucson.

The study also determined the cancer and non-cancer health risk from HAPs. It estimated the excess lifetime cancer risks for the CTC and RME exposure scenarios to be 141 in 1 million and 830 in 1 million, respectively, in Nogales, Arizona. Similarly, the study estimated the excess lifetime cancer risks for the CTC and RME exposure scenarios to be 110 in 1 million and 996 in 1 million, respectively, in Nogales, Sonora. As in the case of PM, these risk rates from HAPs are similar in both communities because the concentrations to which residents are exposed are similar. The study compared these risk levels to risk levels calculated in a comparable manner for the cities of Phoenix, Tucson, Casa Grande, and Payson in Arizona (Figure 12). The study found the cancer risks for the RME exposure scenario in Ambos Nogales were higher than in the other four regions, while the cancer risks for the CTC exposure scenario in Ambos Nogales were about the same as in Phoenix but higher than in the other three regions.

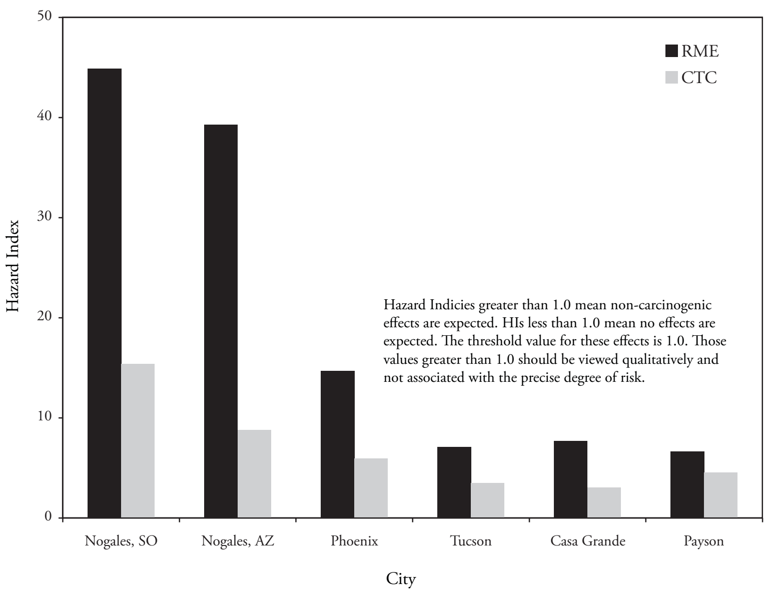
Figure 12. Excess Lifetime Cancer Risks from Hazardous Air Pollutants in Nogales, Sonora, and Nogales, Phoenix, Tucson, Casa Grande, and Payson, Arizona



Note: RME = reasonable maximal exposure receptor; CTC = central tendency case receptor
Source: Arizona Department of Environmental Quality

HAPs produce both carcinogenic and non-carcinogenic risks, the latter of which are expressed in terms of a Hazard Index (HI). In this index, an HI of less than one for a given receptor indicates no adverse non-carcinogenic health effects are expected to occur from exposure to HAPs. For these non-carcinogenic effects, the HI value of 1.0 is considered a threshold value, above which adverse health effects are expected. Because of the inherent limitations in this type of toxicity evaluation, however, the magnitude of the HI cannot predict the precise probability or magnitude of the non-carcinogenic effects. For example, the Arizona and Sonora cites discussed in this chapter (Figure 13) have HIs ranging from three to 45. These statistics only mean that all the cities have airborne contaminants in concentrations that pose a non-carcinogenic risk, not that the city with the highest HI is 10 times riskier for its populace than another.

Figure 13. Hazard Indices from Hazardous Air Pollutants (HAPs) in Nogales, Sonora, and Nogales, Phoenix, Tucson, Casa Grande, and Payson, Arizona



Note: RME = reasonable maximal exposure receptor; CTC = central tendency case receptor
Source: Arizona Department of Environmental Quality

The study found the total HI for non-cancer risks from the selected HAPs for young children, who are the most sensitive, were highest for the selected HAPs that have adverse respiratory effects. The study compared these HI for Ambos Nogales to HI calculated in a comparable manner for Phoenix, Tucson, Casa Grande, and Payson (Figure 13) and found the HI for the RME exposure scenario in Ambos Nogales are much higher than in any of the other four regions, while the HI for the CTC exposure scenario in Ambos Nogales are somewhat higher than in the other four regions. The overwhelmingly dominant cause of both cancer and non-cancer risks from HAPs on both sides of the border was found to be inhalation of organic compounds that result from the operation of motor vehicles.

Studies Related to Asthma Triggers along the Arizona-Sonora Border

Because the binational studies related to health risk assessments for Douglas-Agua Prieta and Yuma-SLRC have not yet commenced, it is difficult to provide reliable information about the health impacts local air quality conditions may be having on community residents. In the short term, an alternative approach would be to examine community-wide disease rates for various illnesses with some potential link to air quality, such as upper respiratory tract infections, asthma, lung cancer, emphysema, or premature death among elderly people with pre-existing heart or lung conditions.

Most of those data are not readily available, but one set of such data that is available comes from three parallel studies of asthma and air quality in Ambos Nogales, Douglas, and Somerton (near Yuma) among fifth-grade students. The time period for data collection in these studies ranged from 1996 (Ambos Nogales) to 2001 (Somerton). The limited ozone and carbon monoxide monitoring that was historically conducted in Ambos Nogales occurred as part of this study. Only one of these studies (Ambos Nogales) was binational, although the researchers hope to fill that gap in future research efforts.

The Ambos Nogales and Douglas studies found a positive correlation between increased respiratory symptoms and increased levels of PM pollution, as well as with temperature and exposure to second-hand smoke. On the other hand, the Somerton study found a positive correlation between increased respiratory symptoms and high or low temperatures, but did not find a correlation with pollution levels or exposure to second-hand smoke. The researchers have suggested that ambient monitoring data in that town may not have been adequate to support a robust statistical analysis. They also found evidence that asthma rates are likely under-diagnosed in all the studied communities. These studies are all summarized in a document titled "Research about Asthma Triggers in the Arizona-Sonora Border Region: A Review" (ADEQ 2004).

Additional Research Needs

Based on the information presented above, as well as knowledge of the communities along the Arizona-Sonora border, additional research is needed in several areas. First, better information is needed about asthma rates and triggers, including air quality. This need is common to all the Arizona-Sonora border communities. The studies mentioned above, focusing on fifth-grade students, provide an important but limited snapshot of the health effects air pollution may be having on the communities. More information is needed about children of other ages as well as adults, and it would be useful to update the study on fifth graders to reflect recent air quality trends. Aspects of additional research needed on asthma triggers relevant to children are described in much more detail in the 2004 ADEQ study. Ideally, these identified research needs would be expanded to include health effects related to air quality in addition to asthma, but because there is limited work already on asthma, and because of current activities to address asthma in all three areas and the Tohono O'odham Nation, this part of the health-related research may be easiest to accomplish.

In addition, research is needed to better characterize heavy-duty diesel truck emissions at the ports of entry in all of the communities, as well as to estimate their health impacts. An important step in this process is being carried out at the Mariposa Port of Entry, where a significant pilot-scale test of three technologies for measuring heavy-duty diesel truck emissions is being conducted. Results of that effort are expected to be available soon.

Another area of research that has been suggested for each of the three sister-city pairs is to investigate the degree to which one monitor on each side of the border is really adequate to represent air quality conditions throughout the area in question. In Ambos Nogales as well as Douglas-Agua Prieta, the extra monitoring sites set up in support of those studies were removed after the air quality data collection phase of the binational studies was completed. The data described above suggest conditions in Douglas-Agua Prieta may be improving, while air pollution in Ambos Nogales may be getting worse. It is not clear whether these trends would look the same if more monitoring sites were maintained.

In Yuma this issue arises in a slightly different context. The one PM monitor that has been in operation there for many years has shown a trend going from violations of the standard to compliance, and then continuing reductions in more recent years, even though the region's population and economic activity have been growing. The planned binational study will likely determine the degree to which monitoring in other locations in the region matches with or differs from this trend. Once the data collection phases of the binational study are over, there may be a need to determine how many monitors are adequate to continue to characterize regional conditions in the future.

In addition to these areas of research need that are common to all Arizona-Sonora border communities, several additional needs have been identified that are specific to one region or another (the order presented here does not imply order of importance). First, as mentioned above, air quality appears to be improving in Douglas-Agua Prieta as well as in Yuma. Some factors that may help explain this trend in Douglas-Agua Prieta are known and described later in this chapter. However, not enough is known about why this trend is occurring to support longer-term air quality management decisions. If local officials could be reasonably certain what factors within their control have helped or could help achieve a positive result, then they would be in a better position to ensure implementation of those activities in the future.

Second, there is a need for ozone and carbon monoxide monitoring in Ambos Nogales to determine whether or not the community may have a compliance issue. The limited monitoring of each parameter that was conducted in 1995 did not occur during the seasons in which those parameters are known to show the highest concentrations.

Third, research needs to be conducted on the potential effects of agricultural burns that include pesticide residues in the Yuma-SLRC area. HAPs regulated under the Clean Air Act do not include pesticides, which means pesticides were not included in pollutants scheduled for attention in the existing studies. In addition, it is not known whether the burning of agricultural crop residues in fields that have been treated with various pesticides may create combustion byproducts not traditionally covered in studies of air pollution from more common combustion sources, such as mobile sources and residential fire places.

Comparative Status of Air Quality Improvement Activities, Current and Planned

As described above, each sister-city pair along the Arizona-Sonora border has had different motivations that brought them into a binational study of air quality. In all cases, those studies have been carried out with the municipal governments as primary partners. However, the manner in which each community has responded to the binational air quality study has differed, with these differences starting while the study was (or is) underway. This section describes the status of current and planned air quality improvement activities in each community.

Ambos Nogales

In 1995—during the early stages of the binational study in Ambos Nogales—the municipality of Nogales, Sonora, took a very important step to improve local air quality. As discussed above, it closed the municipal dump situated in the middle of town and opened a modern landfill to the south of the city, thus eliminating the frequent incidents of burning by scavengers recovering materials. Local residents report that air quality visibly improved after this, and air quality data trends for PM seem to support that observation.

The results of the binational study were presented to the community in August 1999 at a binational meeting in Nogales, Arizona, that included government agencies, community-based organizations, and members of the general public. As a result of the study's release, binational governmental dialogue and public outreach activities were initiated in 2001, with the goal of taking action to improve air quality, and thus public health, in Ambos Nogales. These activities were led by the Mexican and U.S. consuls in Ambos Nogales, together with ADEQ and its sister agency SIUE, and included the participation of the municipal governments on both sides of the border, various other state and federal agencies, and eventually representatives from the business, academic, and community-based organizational sectors as well. The dialogue was first constituted as the Border Liaison Mechanism Economic and Social Development Subgroup (BLM subgroup), which was later expanded and joined by the Border 2012 Ambos Nogales Air Quality Task Force. The task force was established at the BLM subgroup's request. The groups meet jointly and share much of the same membership.

While the binational dialogue was developing its full list of recommendations, several activities were proposed for immediate action. A few of these were implemented. In one, ADEQ conducted traffic count measurements on a number of unpaved roads in Nogales, Sonora, with the hope that this information would help the community determine which roads to pave first for maximum air quality benefit.

The most notable immediate action implemented was a small pilot project to promote revegetation efforts, which has bloomed into the Ambos Nogales Revegetation Partnership (known by its acronym in Spanish, ARAN). Revegetation, including the planting of trees and shrubs, is important in stabilizing the land surface, which leads to reductions in both windblown and fugitive dust.

ARAN is led by the University of Arizona and the Instituto Tecnológico de Nogales in Nogales, Sonora, and includes the active participation of more than 20 partners from local schools, neighborhood groups, the maquiladora sector, community-based organizations, municipal and state government agencies, and organizations from outside the community that bring resources such as experience, technical expertise, and sometimes financial assistance to the table.

Through the effective development and use of this network of partners, ARAN has undertaken a wide variety of revegetation activities in Ambos Nogales, including developing schoolyard habitats and school-based nurseries; training community participants in composting, water harvesting, plant cultivation, worm farming, paper recycling, and community outreach efforts involving a children's puppet show about air quality; establishing neighborhood gardens; securing and improving neighborhood green spaces; improving the municipal nursery in Nogales, Sonora; and many others.

The most advanced of all air quality improvement efforts resulting from the binational dialogue, ARAN's effective use of partnerships serves as a model for implementing other air quality improvement activities in Ambos Nogales. Although a large-scale "greening" of Ambos Nogales may still be distant, ARAN has demonstrated resilience in the face of changes within any one partner organization—a constant feature of social institutions in Ambos Nogales. This resilience suggests ARAN's efforts will be sustained well into the future, whereas many other community-based efforts in Ambos Nogales have lasted only as long as project funding was available.

The binational dialogue led to the identification of 12 recommended actions that should be taken to improve air quality in Ambos Nogales. The implementation status of each of these is shown in Table 3. A review of this information reveals several interesting points. Of the 12 recommended actions, three have both active leadership on at least one side of the border and a draft action plan to help guide implementation. Positive results have been achieved for all three of these actions: ARAN's efforts to promote revegetation, as described above; the receipt by the municipality of Nogales, Sonora, of BECC certification for a major project to pave roads; and the promotion of bicycle use. Another four of the recommendations have active leadership but no developed action plan; of these, three have shown important progress—those focusing on speeding up border crossings, addressing the impacts of the train route, and promoting recycling.

Two recommendations have draft action plans but no active leadership. In these cases, important progress is expected in the near future; however, this progress depends on pilot project grant funding. Not surprisingly, two of the three recommendations that have neither active leadership nor an action plan have seen no progress; the third recommendation that fits those criteria (diesel school bus retrofits) has seen progress because grant funders were eager to move forward on addressing vehicle emissions.

These findings suggest that where active leadership exists, the existence of an action plan seems to have little impact on achieving forward progress. On the other hand, in the absence of active leadership the existence of an action plan can be helpful to obtain funding that will support progress.

The ability or opportunity to work in partnerships appears to have some degree of correlation with the amount of progress that has occurred. The importance of partnerships for ARAN's success has already been mentioned; this partnership formed as a result of BLM subgroup activities. Activities pursuant to the other four recommendations that have realized important progress seem to have had the advantage of well-defined and/or well-understood processes carried out by individuals operating within existing institutional networks, although it should be noted this is an untested hypothesis. In the case of the two recommendations for which progress is expected in the near future (eliminate garbage-burning and reduce wood-burning), it is hoped that partnership networks similar to ARAN will be established as a result of the pilot projects. The remaining five recommendations for which little progress has occurred appear to be challenged by varying combinations of unclear processes, leaders who are not engaged in existing networks that could help achieve implementation, or a need for a new network of institutional partnerships in situations where no activity is either currently occurring or is anticipated to establish such partnerships. It should be noted this, too, is an untested hypothesis.

Table 3. Implementation Status of Air Quality Improvement Activities in Ambos Nogales

Recommended Action	Leaders Identified*	Action Plan Developed**	Primary Implementation Activities	Status of Implementation
A. Stabilize unpaved roads and parking lots	Yes	Yes	BECC-certified program to pave roads in Nogales, Sonora, somewhat targeted according to air quality	Seeking NADB financing
B. Speed up border crossings	Yes	No	FAST and SENTRI lanes being constructed at ports of entry; CyberPort and CANAMEX improvements	Nearing construction of lane improvements; seeking financing on other activities
C. Address vehicle emissions	No	No	Diesel school bus retrofits grant; remote sensing pilot project to characterize diesel truck emissions at border	Setting up contract agreement on retrofits; remote sensing field work nearly complete
D. Construct major corridors	No	No	None	Not started
E. Address impact of train route	Yes	No	First traffic bridge over train route in Nogales, Sonora	Under construction
F. Eliminate garbage burning	No	Yes	Pilot Project to Assess Contributions of Small-Scale Burning to Ambient Concentrations of Air Toxics	EPA funding offered
G. Promote revegetation efforts	Yes	Yes	Ambos Nogales Revegetation Partnership (ARAN)	Network of partners moving from pilot to larger scale activity

Table 3. continued

Recommended Action	Leaders Identified*	Action Plan Developed**	Primary Implementation Activities	Status of Implementation
H. Reduce wood burning	No	No	Thermally designed housing and alternative heating/cooking pilot program	Setting up contract agreement
I. Implement technical solutions to soil erosion	Yes	No	None	Not started
J. Promote recycling	Yes	No	Santa Cruz County recycling program	Nearing completion of grant implementation
K. Improve local transit	Yes	Yes	Border PACT grant to explore promoting bike use	Nearing completion of bike use project
L. Improve traffic flow on local streets	No	No	None	Not started

*Leaders Identified: Officially, leaders in both countries have been identified for all of the recommendations. A "Yes" in this table indicates the leaders from at least one side of the border have either been active in implementation or, if not, then they at least accept this role and are integrated into the Ambos Nogales Air Quality Task Force.

**Action Plan Developed: The Ambos Nogales Air Quality Task Force has agreed that the leaders for each recommendation should develop action plans to guide implementation; these simple guides focus on identifying information such as how much emissions reductions may be realized, how much the recommendation could cost, who the implementation partners should be, how the potential effectiveness of the recommendation will be evaluated, among others. A "Yes" in this table indicates a draft plan has been developed addressing implementation on at least one side of the border."

Source: Authors

Douglas-Agua Prieta

It was obvious from the start of the binational study in Douglas-Agua Prieta that both municipal governments were intent on making the project a success, and both governments were ready to use the study results as a means to find funding sources to mitigate local air quality problems. Also, the willingness of Agua Prieta's officials to work across political party lines for the benefit of their community has been exemplary.

During the early stages of the binational study in 2001, the old municipal dump was permanently closed and replaced with a modern landfill located on the southeast edge of the city, away from the prevailing wind pattern. In addition to moving landfill activities to a better location from an air quality perspective, the modernization resulted in a cessation of the burning activities that had occurred at the old dump during much of the year. In addition, an intensive reforestation effort led by the Agua Prieta mayor's office, consisting of the distribution of 300 trees every weekend, is a part of the city's strategy to improve air quality.

Also in 2001, the *municipio* of Agua Prieta, using ADEQ's data and technical support, started to seek BECC certification for a project to mitigate the dust problem, improve traffic flows, and increase the percentage of paved roads in the city from 19.7% to 27%. The project entailed paving 19.5 miles of existing unpaved roads, modernizing Highway 2, and building bridges to provide better access to different points in the city. On December 17, 2002, Agua Prieta's "Reduction of Suspended Air Particles through Paving" project became one of the first two BECC-certified projects related to air quality (a Ciudad Juárez road-paving project was the other). In December 2003 the North American Development Bank (NADB) approved a $4 million loan to pave 16.7 miles of roads in Agua Prieta. This project has since been completed.

As noted in the previous section, air quality appears to be improving in Douglas-Agua Prieta. This is believed to be a direct result of the ongoing efforts. The proactive role of the two municipal governments, as well as improved air quality in the study area over the last few years, have altered ADEQ's plan to follow the Ambos Nogales model for outreach and governmental dialogue.

Although the binational study has not yet been completed, there is a growing feeling that an Ambos Nogales-style binational dialogue may not be necessary.

Yuma-San Luis Río Colorado

Because the binational study in Yuma-SLRC is at such an early stage, it is not yet appropriate to identify trends or offer hypotheses regarding how or why emission reduction activities are or are not progressing. However, it is possible to identify two sources of PM pollution that either do not exist or exist on a significantly smaller scale in the other sister-city pairs: commercial agricultural activities, including agricultural burns, and brick kiln operations. The municipality of SLRC has already begun an effort to address the brick kilns. Preliminary discussions have been held with kiln operators about the possibility of relocating their operations, although these discussions have been hampered by concerns about land ownership. In addition, the municipality is cooperating with a research effort by Arizona State University to better characterize the degree to which brick kilns affect local air quality, through partitioning studies of PM collected on air quality sampling filters.

Similarities and Differences

Comparing the status of implementation activities related to emission reduction at this time in the three sister-city pairs, it is easy to conclude that there has been much more activity in Ambos Nogales than in the other two areas. However, the binational study for Ambos Nogales was completed several years ago while the binational study in Douglas-Agua Prieta is still underway and, in Yuma-SLRC, has only recently begun. A better basis of comparison would be to look at implementation activities during comparable phases of the binational studies, rather than in the present year. Several interesting points emerge; these are introduced here and discussed in more detail in the following section.

An obvious similarity among all three sister-city areas is that the phases involved in conducting the binational air quality study in each share the same design. Lessons learned in each binational study have allowed improvements to be made within this framework for the next community studied. This continuity may reflect the effectiveness of ADEQ working directly with Sonoran municipal authorities on various aspects of the binational studies, with support and approval from SIUE. The three communities share many types of primary emission sources, although there are a few exceptions noted above, and the relative contributions of source types vary among the three areas.

The differences among these three areas begin with the fact that population and economic growth rates are not the same in each area. Also, the overall air quality situation, including both compliance status and trends over time, is markedly different in each of the three areas. Although it has been possible to conduct the binational air studies with the same phases in each area, the differences will require varying approaches to emission reduction activities in each area. It is not clear whether compliance status drives local leadership, local leadership drives compliance status, or compliance status and local leadership are only circumstantially related; nevertheless it is clear that in Douglas-Agua Prieta, effective leadership by local authorities has resulted in several major air quality improvement actions being completed before the binational air quality study has concluded. In contrast, major air quality improvement actions were not undertaken at the same level in Ambos Nogales until after the binational air quality study was completed, and fewer of these efforts have reached completion or project maturity.

It is possible to identify a clear although varying level of federal role in addressing the major types of emission sources shared by the three communities. However, as individual communities add locally important sources that are not shared by all three (brick kilns in Douglas-Agua Prieta and Yuma-SLRC, electric power generation in Douglas-Agua Prieta, and agriculture-related emissions in Yuma-SLRC), the identification of a federal role generally becomes more challenging. Finally, the fact that Douglas-Agua Prieta and Ambos Nogales truly are sister-city pairs, while Yuma-SLRC is a more complex region, may require some as yet unanticipated changes in the binational study design for this area.

Emerging Patterns of Successes and Challenges

Social Infrastructure

Traditional environmental infrastructure systems, such as those for water delivery, wastewater collection and treatment, and transportation, have long been recognized as sharing certain elements in common. First, each infrastructure system has a series of essential elements. Water delivery infrastructure includes wells, treatment facilities, storage tanks, transmission lines, distribution lines, metered service connections, and indoor plumbing. Wastewater infrastructure must include service connections, lateral lines, collector lines, manholes, treatment plants, discharges, and sludge disposal. Transportation systems must have local roads, interstate highways, multimodal connection points, bus transportation and other forms of mass transit, bicycle lanes, and walking paths.

Second, it is widely recognized that the more redundancy and flexibility any of these infrastructures have, the better they will perform in the face of challenges, whether these challenges come as sudden emergencies (for example, a flood) or ongoing issues such as those posed by ongoing population growth and urban expansion. Third, the systems can vary dramatically in size and complexity, from systems serving a small rural community to those serving a major metropolitan area.

Social infrastructure can play an important role alongside physical infrastructure in the success of efforts to address environmental problems. This has been recognized only recently, and to a limited extent, in the environmental arena. Social infrastructure is the networks of people and institutions who work together toward a common goal, and it can be conceptualized in a manner similar to physical infrastructure. It, too, has a series of essential elements, such as people, institutions, and shared goals; ways and means of coming together to communicate, build relationships, implement agreed-upon activities, and interact with the larger community; and methods for identifying how new participants will join, new directions will be pursued, and challenges will be met. As with physical infrastructure, social infrastructures perform better in the face of challenges if they have more robustness and flexibility built into their structures. Likewise, they can also vary dramatically in size and complexity, as well as in their degree of formality, in terms of both how extensive their rules of operation are and how consciously recognized the network is by its participants.

In discussing the Agua Prieta road-paving project with project participants, it becomes clear Douglas and Agua Prieta have enjoyed a well-developed social infrastructure for environmental work before and throughout the binational study period. Participants often cite continuity within the municipal government through multiple changes in administration and across party lines as one factor contributing to the community's success.

In addition, participants cite a strong history of municipal authorities in Douglas and Agua Prieta working together on environmental projects. One example prior to the recent road-paving project was that Douglas would donate its millings from road repaving projects to Agua Prieta to be used in efforts to better stabilize unpaved roads. Millings are considered a commodity throughout Arizona; thus, Douglas' willingness to donate them to Agua Prieta rather than sell them in the domestic market speaks to the willingness of municipal authorities to support each other.

This crossborder collaboration extends to community-based organizations as well. The Enlace Ecológico, which includes the participation of municipal authorities in Agua Prieta, has collaborated closely with the Border Ecology Project, based in Bisbee. Together, these organizations succeeded in addressing a number of issues related to copper smelters in the region before the binational air quality study even began. Many people have cited this social infrastructure as being directly responsible for the success of the recent Agua Prieta road-paving project, in which the roads paved were chosen specifically and exclusively as those most likely to contribute to improving air quality.

Another example of successful social infrastructure is ARAN. Unlike Douglas-Agua Prieta and its road-paving project, Ambos Nogales had no pre-existing social infrastructure around the issue of revegetation. More broadly, residents of Ambos Nogales have contrasted their own social infrastructure with that of Douglas-Agua Prieta, although many instances of crossborder collaboration between the two municipalities could be cited. Nogales, Sonora, has a long history of lack of continuity from one municipal administration to the next, even though the changing administrations have belonged to the same political party. In addition, although an organization called Living Is For Everyone in Nogales, Arizona, accomplished much of the consciousness-raising about health effects (lupus and multiple myeloma) that led to the binational air quality study, that group had no counterpart across the border with which to collaborate. In this context, ARAN established its social infrastructure largely in a vacuum. Local residents have provided much of the ongoing leadership of ARAN, although initial leadership came from the University of Arizona. This outside assistance—well-tuned to local needs, motivations, and priorities—may have been critical to the ability of such an infrastructure to become established in Ambos Nogales.

One important and shared characteristic of the social infrastructure in both Douglas-Agua Prieta and ARAN has been the fact that local Sonoran residents have participated in these collaborative efforts as equal partners to their Arizona counterparts. It is common for some U.S. participants in border environmental efforts to view their Mexican counterparts as so lacking in financial resources as to present a potential drain for all resources available. However, both the Douglas-Agua Prieta and ARAN partnerships have demonstrated that what the Sonoran participants may lack in up-front financial resources they more than make up for in human capital, energy, and creativity. The Sonoran contribution has been critical to the success of both networks, and ultimately it is the success of these collaborations that has attracted significant financial resources to the projects proposed by both.

These experiences offer several lessons to the Yuma-SLRC region, where the most recent binational effort has been initiated. First, as far as the authors know, Yuma-SLRC does not enjoy the kind of preexisting social infrastructure that Douglas-Agua Prieta has had. This is most likely due to the multi-faceted nature of the Yuma-SLRC area, where the development of such networks would be highly challenging. Local participants in air quality efforts would be well advised to seek opportunities to build partnerships through focused air quality improvement actions even during the earliest stages of the binational study. Preliminary efforts to address emissions from brick kilns may be a good candidate for this purpose.

A second lesson is that where established and relevant social infrastructure exists, local leadership to implement air quality improvement actions arises naturally. Where such infrastructure does not already exist, it can be successfully established. Initial assistance in the form of outside leadership can be quite helpful if conducted correctly. This assistance may even be essential—after all, there must be reasons why local residents and institutions have not been able to establish those networks already in Yuma-SLRC.

Another factor that may help with the establishment of relevant social infrastructure is public outreach, because of its key role in raising awareness among citizens. Although ADEQ has implemented some exemplary outreach efforts in Ambos Nogales, community leaders have often reiterated that these efforts will not be sufficient to create the kind of atmosphere for progress that is needed until many local residents are exposed to air quality data on a regular basis, such as through Air Quality Index/Índice Metropolitano de la Calidad del Aire (IMECA) reporting. In addition, Sonoran officials have repeatedly lamented what they see as a lack of sufficient environmental culture in Mexico, which impedes environmental progress. They believe additional outreach is essential to changing that culture.

The Context of Specific Emission Sources

The similarities and differences among the various important sources of emissions in each sister-city pair have been reviewed above. Regardless of these variations and similarities, each of those emission sources exists in its own framework of laws, policies, social driving forces, levels of relevant governmental authority, and the roles of individuals. To address any source successfully, one must first fully understand that framework. Furthermore, past successes in the Arizona-Sonora border communities have involved going beyond initial understanding of that framework to exercise out-of-the-box thinking about the particular emission source.

The efforts to introduce special commuter lanes at the border in Ambos Nogales had to overcome a history of institutional resistance. Similarly, Agua Prieta chose to finance its road paving without relying on the neighborhood financial contribution traditionally practiced elsewhere; as a result, the roads paved were chosen strictly for environmental reasons, rather than being influenced by which neighborhood happened to assemble its financial contribution first. As another example, ARAN had to overcome the traditional thinking that revegetation efforts, which are as much about community beautification as they are about improving air quality, would not be a priority for people who are not financially well-off.

In addition to the need for creative thinking about emission sources common to the three sister-city pairs, there are some unique sources that may be more difficult to address because of a lack of previous experience in the Arizona-Sonora region. Brick kilns are one example. While Arizona-Sonora efforts can certainly draw upon the experience of the Paso del Norte airshed in addressing brick kilns, it should also be recognized that the level of relevant social infrastructure in Paso del Norte—including eight universities and institutions of higher learning, a large point source emitter with a legal obligation to invest in emissions reduction activities, and several international public health organizations with a long history of collaboration—will never be matched along the Arizona-Sonora border. Another example is emissions associated with agricultural tillage practices and agricultural burning. Although some efforts have addressed emissions from these kinds of sources in the United States, there has not previously been a binational effort along the U.S.-Mexican border to address such emissions.

Activity Design and Targeting: What Can Be Controlled

Successful efforts by Douglas-Agua Prieta, ARAN in Ambos Nogales, and others described above show the design and targeting of emissions reduction activities can be effectively controlled by local participants. Particularly in the case of Douglas-Agua Prieta, this successful design and targeting of emissions reduction activities may play a role in why local air quality has been improving in recent years. Undoubtedly, successful design and targeting is directly related to why the ARAN partnership has developed so effectively.

At the same time, other ideas have been proposed that reflect good design and targeting and yet they have not been implemented to date. The reasons have not been fully evaluated, although the factors described above suggest that lack of social infrastructure likely plays an important role. Other factors may include lack of prior experience, difficulties associated with promoting and executing out-of-the-box thinking, and an inability of local and state leaders to act on their good plans for various reasons. A thoughtful evaluation of the reasons that various activities have not yet been implemented—one that does not point fingers at particular people but instead looks for unused opportunities—would be helpful.

Population Growth and Weather: What Cannot Be Controlled

Although the design and targeting of activities can be effectively controlled by local participants, there are other factors with the potential to affect air quality that are beyond the ability of local or even state-level participants to control. Most notable among these are the weather and population growth, and associated economic growth. As described earlier, the three sister-city pairs along the Arizona-Sonora border have significant differences in terms of population and economic growth.

There has been relatively little growth in Douglas-Agua Prieta, and this situation is expected to continue for the foreseeable future. It is not known to what degree the local improvement of air quality is attributable to specific emissions reduction activities taken by the community, or simply due to a combination of low growth rates and lucky weather conditions.

Yuma-SLRC, while much bigger than Douglas-Agua Prieta, also has experienced a lower growth rate than Ambos Nogales. This may help explain why Douglas, which has been in nonattainment status but has seen a reduction in 24-hour PM_{10} concentrations, may soon be redesignated as a “maintenance” area. A violation of the 24-hour standard that occurred in 2002 was a potential obstacle to that redesignation, but it was subsequently determined to be the result of a high wind episode, a natural event that justifies a waiver by EPA. The community hopes implementation of BACM and a public education program, as required under a NEAP, as well as submittal in summer 2006 of a Maintenance Plan and re-designation request to EPA, will help complete the process of being reclassified.

Ambos Nogales, on the other hand, has continued to experience dramatic population and economic growth in spite of the economic downturn of recent years. As noted above, this growth may explain why the community has returned to violations of air quality standards in recent years. The most recent data available have shown air quality improvements, which may be related to a mild winter. All these factors are beyond the control of local leaders. In addition, the high rates of population and economic growth may be an obstacle to more extensive efforts to establish successful social infrastructure to address environmental issues.

Rural Needs Vis-à-Vis National Policy Initiatives

Because national policy initiatives often tend to be informed by a perspective that focuses on the grand scale and large populations, the needs of rural areas can easily be overlooked or lost amid the many competing priorities. In spite of this, both Douglas-Agua Prieta and Ambos Nogales have made progress by taking advantage of the expanded mandate of BECC and NADB, which added air quality as an area of concern in 2000 (see Chapter VII). As mentioned above, Agua Prieta has already completed its road-paving project with NADB financing. Nogales, Sonora, has received BECC certification for its road-paving project and is currently pursuing NADB financing.

However, there are a number of other issues on which the Arizona-Sonora rural sister cities need policy attention at the federal level. Some of these needs are likely to gain that attention in coming years because they are also shared by larger, more urbanized areas in the two countries. One example is the need to make ultra-low-sulfur diesel fuel available throughout Mexico. This fuel will reduce PM somewhat in existing engines, but more importantly will be the only fuel that new engines in model year 2007 can use, and those new engines will reduce PM and NO_x dramatically. A second example is the development of $PM_{2.5}$ standards in Mexico, thus establishing a regulatory framework parallel to the existing one in the United States.

Other rural issues may be harder to address in a national program. It has already been mentioned that efforts to address agricultural emissions will be new in the binational context. Also, establishing a social infrastructure to address specific air quality issues, where none exists now, may be challenging without outside help.

Addressing sources where no social infrastructure exists and where defining a federal role is difficult may be doubly challenging. One such issue on which the Arizona-Sonora border region hopes to see some progress in the coming year is wood-burning in Ambos Nogales. EPA funding has been made available through ADEQ to support a community assessment by the University of Arizona similar to that which established the ARAN partnership. The project workplan defines federal and state roles intended to result in the development of social infrastructure. If success is attained, then a desirable role for the federal government may be to help finance the larger-scale implementation of approaches to reducing wood-burning that are identified in this pilot project. This may include, for example, the use of mechanisms established by the Kyoto Accord (see Chapter VI).

At the state level, ADEQ has undertaken a project to improve the environmental health conditions of children. One of the key priority concerns is identifying asthma triggers and undertaking binational outreach efforts to inform school officials and other local leaders, parents, and children about asthma and how to treat it. While this program focuses on one population group, the overall research and outreach efforts will benefit all residents of the border. Effective communications and practical low-cost opportunities, such as voluntary reduction of school bus idling, are the mechanisms being developed for this project within the border region. Although these efforts have had some success to date, they could be more effective if better data were available about asthma rates and the prevalence of a variety of asthma triggers, including air quality.

Although limited research on these issues has been conducted along the Arizona-Sonora border, most such border area research is conducted in larger population centers elsewhere on the U.S.-Mexican border.

Financing Is Key—Or Is It?

One final pattern of successes and challenges worth exploring further has to do with the financing of air quality improvement efforts. Several efforts to obtain financing have been mentioned above. In fact, all successful efforts to reduce emissions that have been implemented to date along the Arizona-Sonora border have needed and obtained significant levels of financing. However, funding has not created the social infrastructure networks that have also been so key to various projects' success. On the contrary, it has been seen that the opposite happens: once a network is successfully established, then that network is able to attract the necessary financing. Thus, while funding is necessary for emission reduction actions to be implemented, a relevant social infrastructure may be an essential pre-requisite to obtaining and using the available funding.

Conclusions

Rural Conditions in a Binational Program: The Square Peg

The previous section explored several of the difficulties faced by rural areas participating in a binational program. In short, the Arizona-Sonora border area will never have the high level of resources and institutional frameworks present in areas like the Paso del Norte airshed or San Diego-Tijuana. In addition, it can be challenging to define a federal role in addressing some of the pollution sources important to various parts of the Arizona-Sonora border, but that are not necessarily important sources in larger and more urban settings. Nevertheless, certain advantages have been identified with respect to rural areas. Chief among these is that establishing social infrastructure associated with binational cooperative air quality efforts may be simpler than in larger areas. The Arizona-Sonora border region should take better advantage of its state-to-state network for cooperation in order to help transfer lessons learned among its sister cities and to help create needed social infrastructure where it is currently lacking.

Priority Policy Issues Needing Attention

It is relatively easy to identify those interests of one or both of the federal governments that benefit both the urban areas and the rural areas. These include making ultra-low-sulfur diesel fuel available throughout Mexico, establishing $PM_{2.5}$ standards in Mexico, and upgrading the infrastructure at ports of entry. Continuing progress in these and other areas where the federal role is clear will be helpful to Arizona-Sonora's border area.

Equally important are federal and state resources to help establish local social infrastructure where needed to address specific and locally important emission sources, regardless of the importance of those sources in urban areas or at a national level. Even when no other specific federal role can be defined, the ability of the federal governments in both countries to offer financing mechanisms often transcends the capabilities of state, and especially local, governments. At the same time, the first focus of that funding, or of local efforts leading to funding, should be the establishment of effective partnerships among stakeholders.

Successes, Challenges, and their Broader Lessons

Much of this chapter has focused on comparing and contrasting the three primary sister-city pairs along the Arizona-Sonora border, and some attention has also been paid to the challenges and opportunities posed by being a rural area in a federal, binational program. However, the Arizona-Sonora border region does have some lessons to offer the rest of the U.S.-Mexican border region on air quality.

First, the Agua Prieta road paving project was one of the two projects first certified by BECC and financed by NADB when those institutions added air quality to their portfolio of criteria. That project established a standard by which environmental improvement drives the decision-making, and financing methods follow, rather than the other way around. The entire border area would benefit from adopting this model.

Second, social infrastructure is very important to success, including success at obtaining significant funding for air quality improvement actions. The experience in Douglas-Agua Prieta demonstrates how any community with an existing social infrastructure can take advantage of that infrastructure to realize measurable air quality improvements. In Ambos Nogales, ARAN is an example of how effective, relevant networks can be established where they did not previously exist.

Third, it is often true of successful binational air quality improvement efforts that the Sonoran participants contribute as equal partners with the Arizona participants. Recognizing that financial resources are not the only resources that matter, and that Mexican stakeholders can more than make up for having less money with the creativity and energy they bring to the table, can be a valuable step forward for any community seeking to accomplish binational air quality improvements.

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