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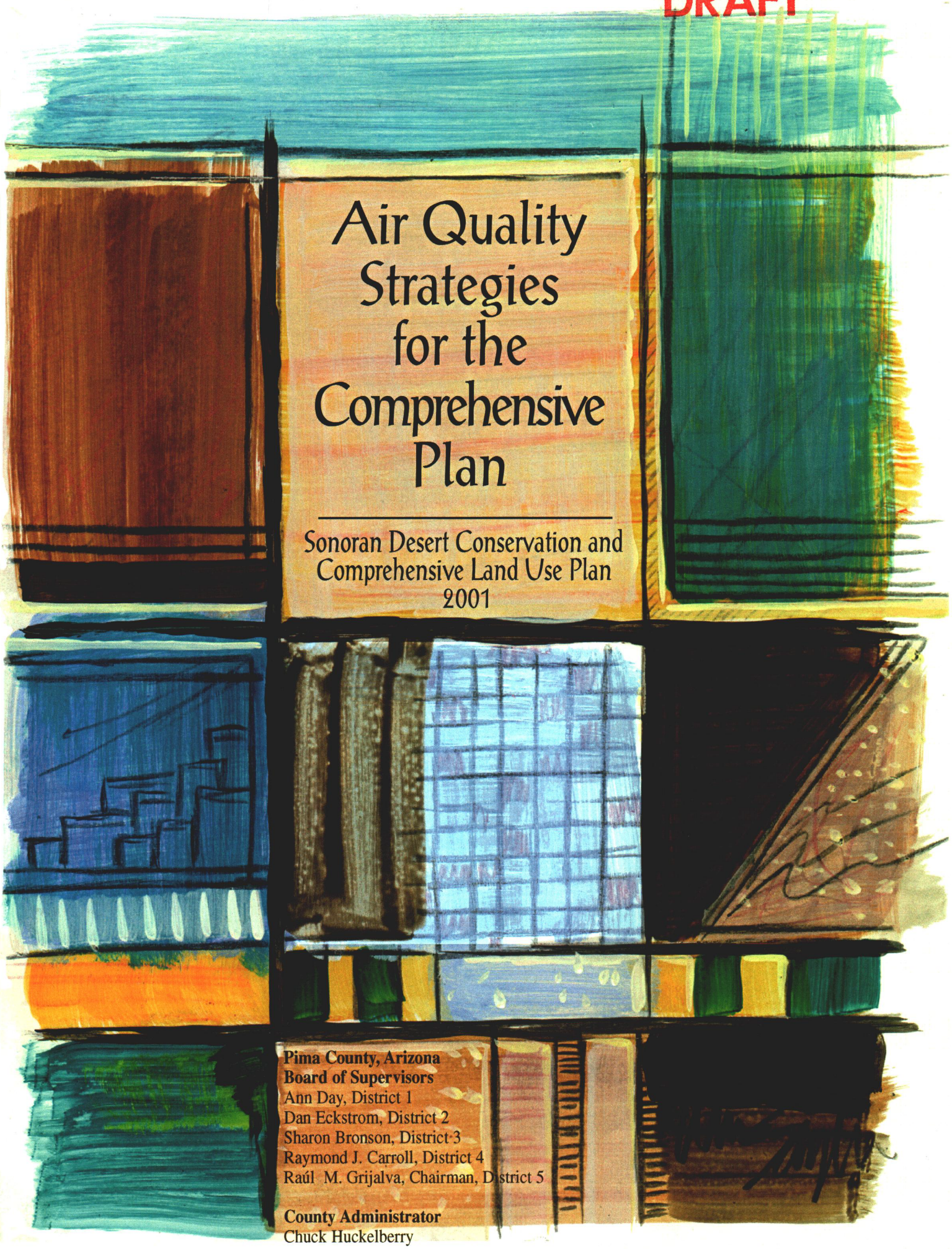

Air Quality Strategies for the Comprehensive Plan

Sonoran Desert Conservation and Comprehensive Land Use Plan 2001

Pima County, Arizona
Board of Supervisors
Ann Day, District 1
Dan Eckstrom, District 2
Sharon Bronson, District 3
Raymond J. Carroll, District 4
Raúl M. Grijalva, Chairman, District 5

County Administrator
Chuck Huckelberry

MEMORANDUM

Date: September 10, 2001

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Air Quality Analysis**

Background

Air quality is identified under the state law that defines the elements the Comprehensive Plan as one aspect of the Environmental Planning Element. Growing Smarter Plus requires "analysis, policies and strategies to address anticipated effects, if any, of plan elements on air quality, water quality and natural resources associated with proposed development under the comprehensive plan." The state law also calls for "consideration of air quality and access to incident solar energy for all general categories of land use." The attached study generally confirms the trends and impacts identified in the February 2001 study entitled *Air Quality in Pima County*, and suggests two types of strategies for maintaining air quality and ensuring compliance with federal air quality standards: (1) air quality control program improvements, and (2) research and monitoring programs. Potential funding sources and future legislative considerations are briefly discussed.

Trends in Air Quality and Relevance to Land Use Planning

Carbon monoxide: In 1978 Tucson was designated as being in nonattainment based on carbon monoxide concentrations. After implementation of effective corrective programs, the Environmental Protection Agency redesignated the area to the status of "maintenance." Keeping carbon monoxide levels low will be a challenge in the future as the number of vehicle miles being traveled increases with population growth and Tucson's automobile dependent lifestyle.

Ozone: Ozone trends are described as nearing the threshold for violation of national standards.

Particulate: Particulate trends exceeded standards at times during 1999, leading to the creation of a Natural Events Action Plan by Pima County's Department of Environmental Quality.

Who Regulates Air Quality in Pima County?

The Clean Air Act, passed in 1970 to establish standards through the Environmental Protection Agency, is administered primarily through state and local governmental entities. In Pima County, three entities have roles: the Arizona Department of Environmental Quality; the Pima County Department of Environmental Quality; and the Pima Association of Governments.

The Arizona Department of Environmental Quality (ADEQ) has the primary authority in the State of Arizona for air pollution control and abatement.

The Pima County Department of Environmental Quality (PDEQ) is the local air pollution control agency for Pima County with jurisdiction over air pollution sources not under state jurisdiction and delegated authority from the State to (1) regulate certain stationary sources and portable air pollution sources, and (2) operate the Voluntary No-Drive Days (Clean Air) Program. PDEQ is responsible for monitoring the ambient air quality of the region by collecting and analyzing air quality data.

Pima Association of Governments is designated as the lead air planning organization for Pima County and addresses regional air quality issues in keeping with federal, state, and local requirements.

Potential Strategies to Control Emissions and Increase Available Information

It is significant for purposes of land use planning that 70 percent of the air pollution in the region comes from motor vehicle emissions, trains and airplanes, as opposed to stationary sources such as business and industry. The following programs reflect the extent to which air quality programs are transportation control measures:

- Federal Motor Vehicle Emissions Control Program
- Arizona Vehicle Emissions Inspection Program
- Arizona Oxyfuels Program
- Pima Association of Governments Travel Reduction Program
- Pima County Voluntary No-Drive Days (Clean Air) Program
- Pima County Voluntary Vehicle Repair and Retrofit Program
- Pima County Voluntary Lawn and Garden Equipment Collection Program
- Mass Transit
- Rideshare Program

The attached study suggests the following strategies to keep emissions as low as possible.

Market based programs: Emissions trading programs are thought to be more cost effective than non-incentive based regulatory schemes.

Coordination with land management agencies: Prescribed burns add to the pollutant load, therefore joint planning with air quality regulators is suggested in order to allow for the minimization and mitigation of impacts.

Landscape standards: Increased vegetation and tree planting would reduce the heat island problems found in urban areas and thus reduce energy demands by individuals.

Building code standards: Five different building code standards are promoted by the study in the areas of natural gas fireplaces, solar water heaters, and features that promote telecommuting, electric vehicle use, and use of renewable energy sources.

Transportation related measures: In the area of transportation, a number of suggestions are offered, ranging from increased incentives and penalties to reduce emissions, measures to maximize transportation system capacity, and land use decision making that encourages clustering land uses so trips and vehicle miles traveled are reduced as people drive from residential to business and commercial areas. Road paving is encouraged, along with measures to increase the use and availability of transit.

Research: A number of research activities are proposed to expand available information about air quality. These include expanding the monitoring network, improving modeling capability, developing an emissions inventory, and studying the impact of poor air quality on natural systems.

Implementation issues of funding and legislative authority: In general, Pima County is limited in its ability to improve air quality through some measures since state law does not allow the County to adopt standards that are more stringent than the existing state standards. An exception exists when a unique local condition is proven to exist and there is a significant threat to public health or such a measure is necessary to meet a federal standard. Funding for additional program improvements through fees is similarly constrained.

Conclusion

While air quality is one of the most highly regulated of resources, additional analysis is needed to better understand the impact of poor air quality on human health and natural systems. Establishing a credible factual predicate should be a priority of Pima County under work programs that might result from adoption of the Comprehensive Plan Update.

Attachment

PIMA COUNTY
DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR QUALITY STRATEGIES
FOR THE
COMPREHENSIVE PLAN

2001

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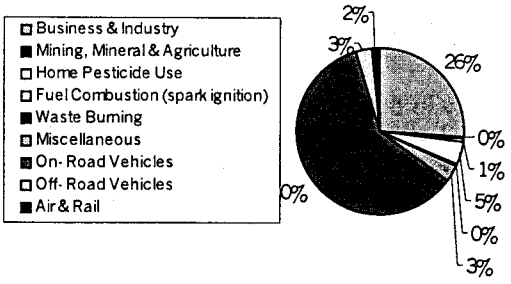
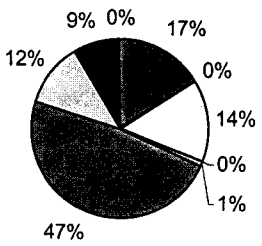
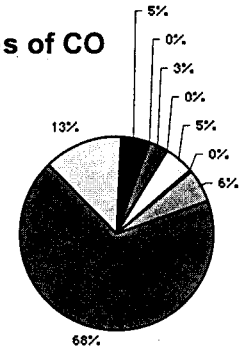
Sources of VOCs



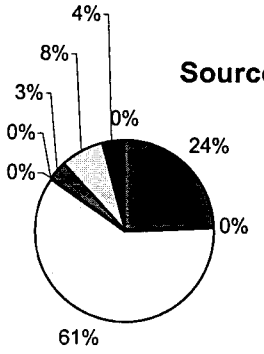
Sources of NOx



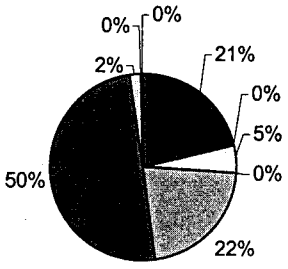
Sources of CO



Sources of SOx



Sources of PM



Source: PDEQ's 1995 Emission Inventory Report

As the region sees increased motor vehicle travel, the gains in air quality will be eroded. Historical trends suggest that the region will see increased use of the motor vehicle travel, and the increase will be at a greater rate than the increase in new residents to the region. According to Pima Association of Governments, over the last 20 years population in the metropolitan area increased 61%, from about 520,000 in 1980 to 853,000 in 2000, while demand for travel, measured in daily vehicle miles traveled or VMT, increased approximately 144%, from 7.2 million miles in 1980 to 17.7 million miles in 2000. This trend is due, in part, to rising incomes, which brings more discretionary travel, and decreases in household size. Probably the single greatest factor that contributes to the increase in vehicle miles traveled is the sprawling nature of growth in the region. Increased distances between new residential development and major activity centers lengthens the typical trip, and results in an overall increase in the number of miles that are traveled by households.

One might seriously question whether this trend can be sustained for a variety of reasons. In terms of air quality alone, it means that the region may violate ozone standards within the next several years, and in the long term, other air quality standards. A violation in air quality standards means that the air is unhealthy to breathe by the most sensitive populations, such as children playing outdoors, the elderly and those with respiratory illnesses.

In addition, poor air quality jeopardizes what makes this part of the world so special. The Tucson area enjoys very close proximity to the Saguaro National Park, Coronado National Forest, and wilderness areas. Air pollution also can result in haze, which degrades visibility and obscures the clarity, texture, and form of the surrounding natural world. In purely monetary terms, poor air quality may reduce the number of visitors bringing revenue to Pima County.

In the discussion that follows, specific air pollution elements and trends are identified, impacts of poor air quality are explained, and a context for regulating air quality is established, setting the stage for discussion of mitigation strategies. Since mobile sources, such as cars, buses, planes, trucks, and trains, are responsible for more than 70% of air pollution in Pima County, many of the mitigation strategies focus on transportation control measures.

CHAPTER TWO

POLLUTANTS AND POLLUTANT TRENDS

Pollution sources emit a wide variety of pollutants. The six criteria pollutants addressed in the NAAQS are Carbon Monoxide, Ozone (or smog), Particulate Matter, Lead, Nitrogen Dioxide, and Sulfur Dioxide. The table below provides NAAQS for each of the six criteria pollutants. A description of these pollutants and local and national trends are presented in the discussion that follows.

Table 2-1

National Ambient Air Quality Standards

POLLUTANT	STANDARD VALUE *		STANDARD TYPE
Carbon Monoxide (CO)			
8-hour Average	9 ppm	(10 mg/m^3)	Primary
1-hour Average	35 ppm	(40 mg/m^3)	Primary
Nitrogen Dioxide (NO_2)			
Annual Arithmetic Mean	0.053 ppm	(100 μg/m^3) **	Primary & Secondary
Ozone (O_3)			
1-hour Average	0.12 ppm	(235 μg/m^3)	Primary & Secondary
8-hour Average **	0.08 ppm	(157 μg/m^3)	Primary & Secondary
Lead (Pb)			
Quarterly Average	1.5 μg/m^3		Primary & Secondary
Particulate (PM 10) *Particles with diameters of 10 micrometers or less*			
Annual Arithmetic Mean	50 μg/m^3		Primary & Secondary
24-hour Average	150 μg/m^3		Primary & Secondary
Particulate (PM 2.5) *Particles with diameters of 2.5 micrometers or less*			
Annual Arithmetic Mean **	15 μg/m^3		Primary & Secondary
24-hour Average **	65 μg/m^3		Primary & Secondary
Sulfur Dioxide (SO_2)			
Annual Arithmetic Mean	0.03 ppm	(80 μg/m^3)	Primary
24-hour Average	0.14 ppm	(365 μg/m^3)	Primary
3-hour Average	0.50 ppm	(1300 μg/m^3)	Secondary

**The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. *Primary standards* set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. *Secondary standards* set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

Carbon Monoxide (CO)

Carbon Monoxide is an odorless, colorless gas produced by the incomplete burning of carbon-based fuels, including gasoline, oil, and wood. After being inhaled, CO molecules can enter the bloodstream, where they inhibit the delivery of oxygen throughout the body. Low concentrations can cause dizziness, headaches, and fatigue; high concentrations can be fatal.

CO is emitted from industrial processes, but the primary source of CO is motor vehicle exhaust. In Pima County, over 70% of the CO in the atmosphere is from motor vehicle exhaust. Other sources are from off-road vehicles, trains and aircraft. CO is found in high concentrations along the roadside, especially where there is heavy traffic. CO concentrations tend to be highest in winter, when temperatures are cool, wind speeds are low and a temperature inversion is present. This occurs when a stable atmospheric layer restricts the mixing of pollutants.

Carbon Monoxide Trends

In the 1970s and early 1980s, Pima County frequently did not meet the standards for carbon monoxide. As a result, the EPA designated the Tucson region as a "nonattainment area" for CO. Please see Figure 2-1, showing the CO nonattainment area.

During that same time period, the federal tailpipe emission standards for new cars had been modified to significantly reduce CO emissions from motor vehicles. Several programs were implemented locally to combat carbon monoxide emissions, including the Oxygenated Fuel Program, the Vehicle Emissions and Inspection Program, the Travel Reduction Program, the Clean Air Program, improvements to mass transit and various transportation control measures. Since 1984, no violations of the CO NAAQS have been recorded and CO is not currently considered to be a health threat in the Tucson region.

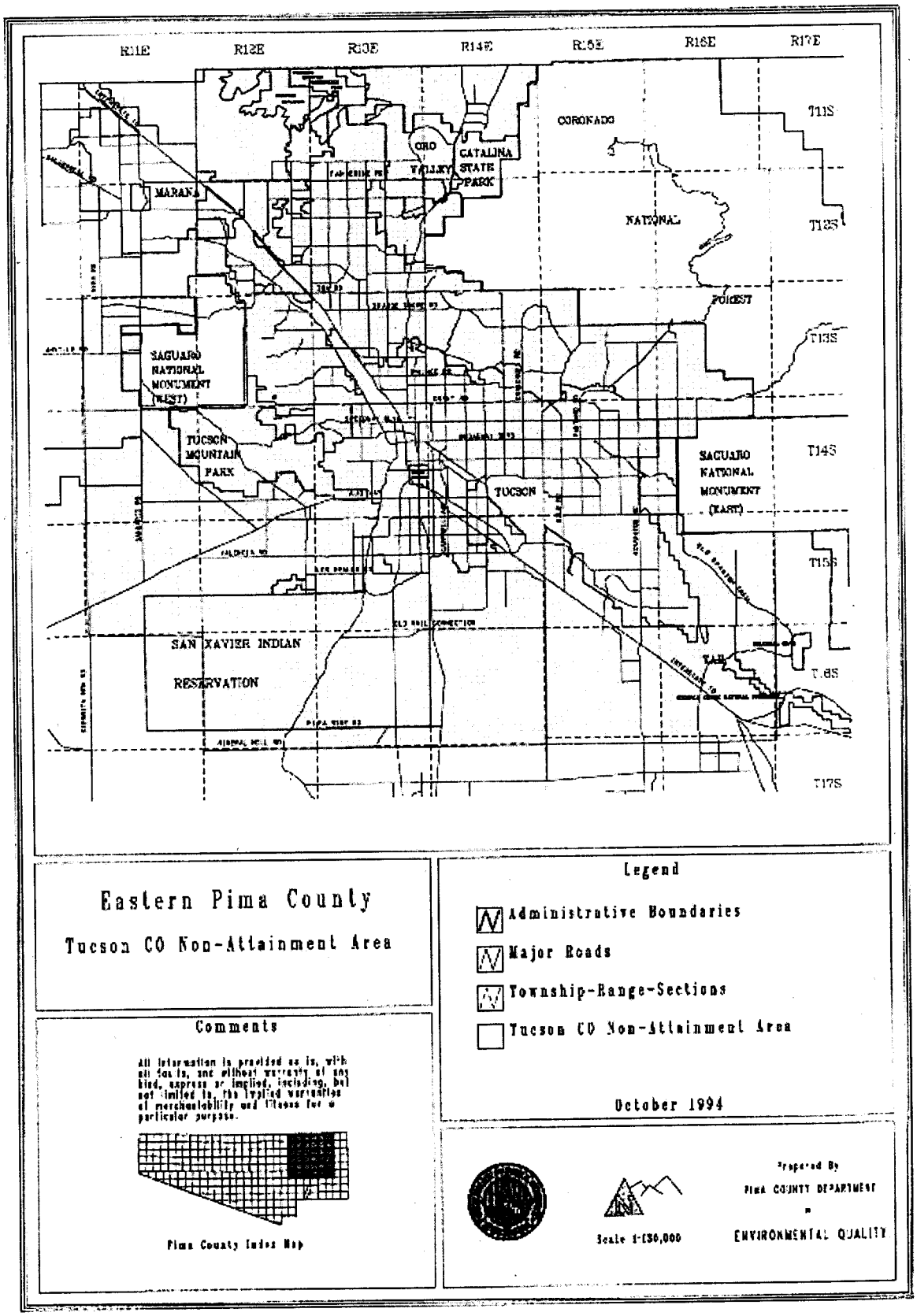
In the year 2000, the EPA redesignated Pima County from a nonattainment area for carbon monoxide to a maintenance area. As a maintenance area, Pima County is required to maintain existing control measures for CO, to assure that the levels of this pollutant are maintained below the NAAQS. The maintenance area plan for CO, known as the Carbon Monoxide Limited Maintenance Plan, also includes requirements for monitoring major hot spot intersections in the Tucson metropolitan area to analyze trends in CO levels.

The Limited Maintenance Plan includes an attainment emissions inventory, verification of continued operation of the monitoring network and a contingency plan. The contingency plan provides a procedure to prevent violations of the NAAQS. A trigger event occurs when a CO level exceeds 85% of the standard for the 8-hour average. If two such events occur at any one site in any CO season (October through March), a pre-violation action level is reached. This will prompt further field studies, technical evaluations and modeling. Recommendations and implementation of mitigation measures, if necessary, will then take place. Hot-spot events will likely be addressed with local mitigation measures, such as transportation system improvements. If the problem were area-wide in nature, measures such as increasing the oxygen content of fuel would be considered for implementation.

Nationally, trends are similar to those in Pima County. Total CO concentrations decreased 39 percent during the past 10 years and emissions from all transportation sources have decreased 16 percent. Despite a 23-percent increase in vehicle miles traveled (VMT), emissions from on-road vehicles decreased 24 percent during the past 10 years, as a result of federally mandated automotive emissions control programs.

In Pima County, current levels of CO remain below 40 percent of the NAAQS, but with population continuing to grow in Pima County and more vehicle miles being traveled, these levels could increase in the future.

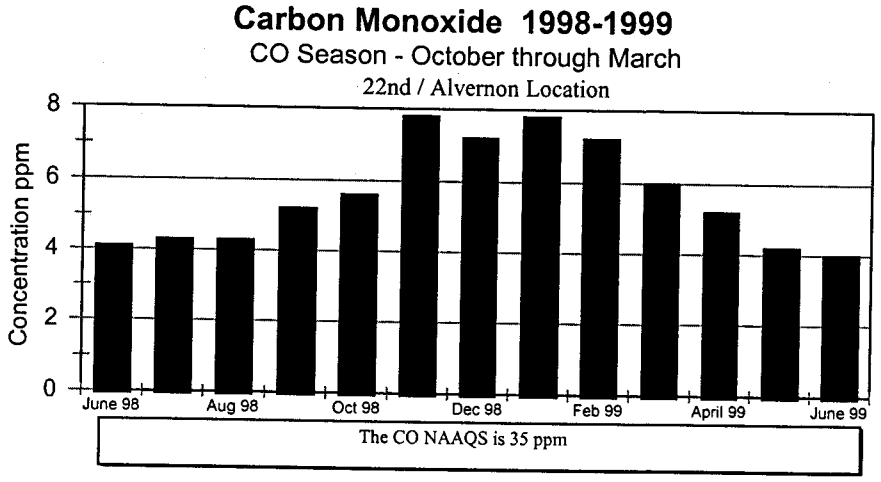
Figure 2-1 showing the nonattainment area for CO



Source: PDEQ 1994 Map

Some recent trends in carbon monoxide levels are as shown below:

Figure 2-2

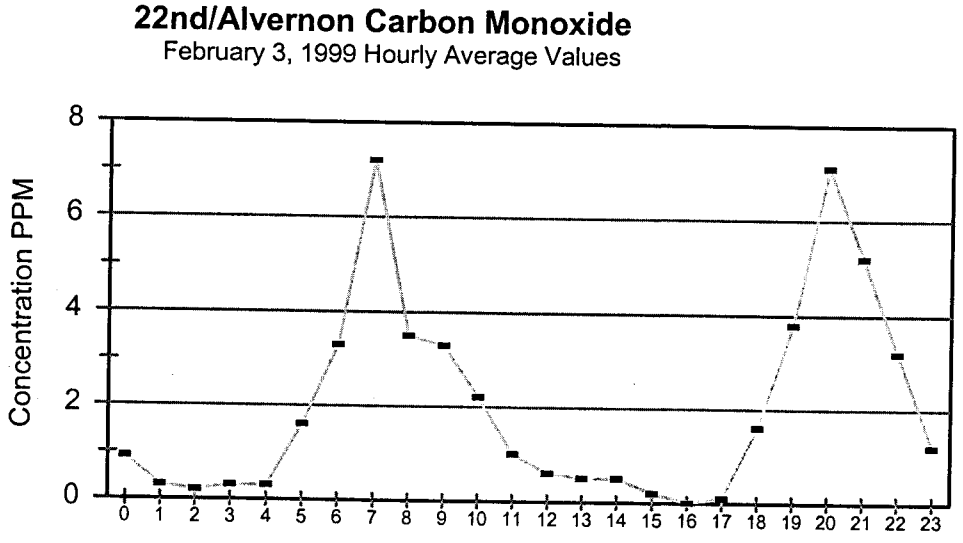


Source: PDEQ's 1999 Air Quality Summary Report

As seen from the figure above, the Tucson area generally has highest CO readings in the winter months. October 1 through March 31 is considered the CO season. This is primarily due to stagnant air condition in the colder winter mornings. This condition causes pollutants to accumulate close to the ground, and high concentrations of CO are normally found near congested intersections.

Daily Trends

Figure 2-3



Source: PDEQ's 1999 Air Quality Summary Report

Figure 2-3 illustrates how the carbon monoxide values follow the traffic flow. The rush hour traffic becomes more congested and slower moving, causing higher levels of carbon monoxide to build up and be recorded at the monitoring site.

CO is a localized pollutant that disperses rapidly. High CO concentrations tend to occur when wind speeds are low and strong inversions are present. The figure above illustrates how the carbon

monoxide values follow the traffic flow. The rush hour traffic becomes more congested and slower moving, causing higher levels of carbon monoxide to build up and be recorded at the monitoring site.

Ground-Level Ozone (O_3)

Ozone is a gas that is a variety of oxygen. Oxygen consists of two oxygen atoms; ozone consists of three. Ozone in the upper atmosphere, where it occurs naturally in what is known as the ozone layer, shields the Earth from the sun's dangerous ultraviolet rays,

Ground-level ozone is not emitted directly from mobile or stationary sources. Ground-level ozone comes from a series of complex photochemical reactions involving the breakdown (oxidation) of volatile organic compounds. It is formed in the atmosphere through chemical reactions involving VOCs, NOx and sunlight. The rate at which the reactions proceed is related to both temperature and intensity of the sunlight. Elevated O_3 levels typically occur on hot summer afternoons. Typical urban area sources NOx and VOCs are emissions from cars, buses and trucks and off-road mobile sources (such as construction vehicles, planes and trains), power plants and factories.

Ozone levels may paradoxically be as high or higher downwind from cities than in the cities themselves, reflecting the time needed for the atmospheric photochemical reactions to occur. Similarly, when air masses are stagnant for a few days, precursor concentrations rise and react in the sunlight resulting in exceptionally high levels. This is most likely where large urban areas are surrounded by mountains, such as Los Angeles and Mexico City.

Ozone Trends

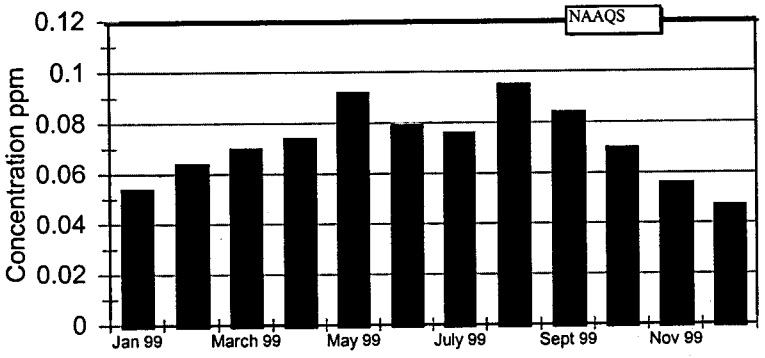
As illustrated by the figure below showing ozone readings for one location, the levels of ozone in general are higher in the summer months. This is due to intense sunlight, high heat, and stable air conditions. Ozone precursor pollutants, oxides of nitrogen and VOCs, react in the presence of sunlight and heat to form ozone.

Figure 2-4

Ozone Season 1999

O3 Season - March through September

Monthly High One Hour Average, 22/Craycroft Location



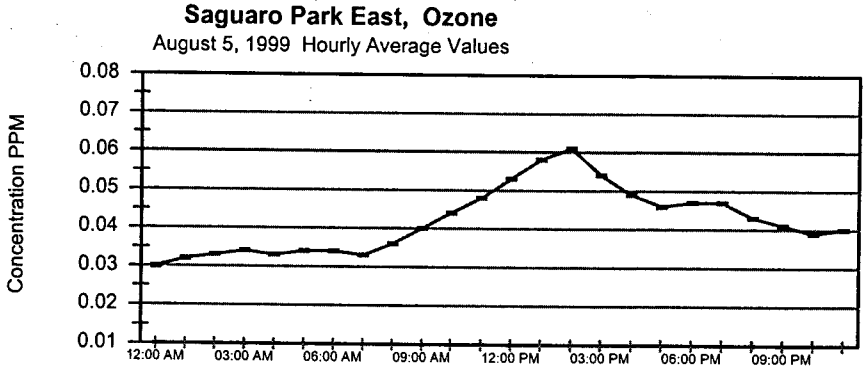
Source: PDEQ's 1999 Air Quality Summary Report

The fluctuation in ground-level ozone is due more to changing weather conditions than to lower emissions from any particular source. Since the major source of precursors to ozone is motor vehicle use, concerns rise as the county's population continues to grow and more cars are being driven more miles in Pima County.

Figure 2-5 shows the daytime cycle of ozone in the Tucson area. As the sun begins to react on the VOC's and NO_2, ozone levels begin to rise. This rise continues through the day, as long as there is

sunlight, or until either the VOC's or the NO_2 is exhausted. Once this point is reached the levels begin to drop. At night the VOC and NO_2 levels may rise but without the sun to act on them ozone will not be produced.

Figure 2-5



Source: PDEQ's 1999 Air Quality Summary Report

Figure 2-5 shows the diurnal cycle of ozone in the Tucson area. As the sun begins to react on the VOC's and NO_2, ozone formation rises. This rise continues through the day, as long as there is sunlight, or until either the VOC's or the NO_2 is exhausted. Once this point is reached the levels begin to drop. At night the VOC and NO_2 levels may rise but without the sun to act on them ozone will not be produced. Since ozone monitoring began in Pima County in 1973, levels have remained fairly uniform throughout the Tucson metropolitan area. EPA promulgates standards based on both one-hour values and eight-hour averages. The PDEQ monitoring network last recorded an exceedance of the one-hour NAAQS for ozone in 1983. However, long-term trends (1984-1999) show that the highest ozone levels have been measured consistently at about 90% of this standard.

With respect to the eight-hour ozone standard, monitoring data indicate that four of the seven monitoring sites in the Tucson area are near this standard. Thus, it is possible that the eight-hour ozone standard will be violated within the next few years, especially given the strong influence of meteorology on ozone formation.

One of the most effective controls for the country has been the Federal Motor Vehicle Control Program. This has reduced nitrogen oxide and hydrocarbon emissions by placing stringent emissions regulations on auto manufacturers. Modeled forecasts of future emissions from on-road vehicles indicate a significant downward trend in the medium-to-long term due to increasingly stringent emission standards for new vehicles. In other words, the replacement of older vehicles with newer vehicles is projected to overcompensate for growth in the number of vehicles and total vehicles miles traveled. On the other hand, emissions from off-road vehicles and stationary sources should increase roughly in proportion to the population, thereby moderating the downward trend in mobile source emissions.

While Pima County is experiencing fairly uniform O_3 levels, nationally, 1-hour O_3 concentrations have declined 17 percent since 1979. National total VOC emissions (which contribute to ozone formation) from man-made sources decreased 20 percent between 1989 and 1998. National total NO_x emissions (the other major precursor to ozone formation) increased 2 percent over the same 10-year period, although changes in data availability and methodology between 1989 and 1990 (in the other combustion category) introduce uncertainty in this comparison.

Particulate Matter

Particulate Matter is any type of solid in the air in the form of smoke, dust, and vapors, which can remain suspended for extended periods. PM_{10} and $PM_{2.5}$ are terms used to describe small particles suspended in the air. PM_{10} refers to the range of particles 10 micrometers or less in size. $PM_{2.5}$ is a

subset of PM_{10}, having a size of 2.5 micrometers or less. Particle composition can include everything from fine dust to carbon (soot), and can be microscopic or visible to the naked eye.

Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, fossil fuels, mixing and application of fertilizers and pesticides, road construction, industrial processes (such as steel making and mining), agricultural burning, and operation of fireplaces and wood stoves. Particulate matter in Pima County is generated from a variety of sources including traffic on unpaved roads, unpaved shoulders, and paved streets, combustion, earth-moving, mining, construction, and agricultural activities. In Pima County, the natural desert background comprises about one-third of the typical urban PM_{10} concentrations.

Microscopic particles in the air can be breathed into lung tissue becoming lodged and causing increased respiratory disease and lung damage. Particulates are also the main source of haze, which reduces visibility.

Particulate Matter Trends

In 1971, EPA defined particulate matter as finely divided materials that have an aerodynamic diameter less than 100 micrometers, and particulate matter was measured as total suspended particulates (TSP). In 1977, the metropolitan Tucson area of Pima County exceeded the NAAQS for particulate matter and was designated as "non-attainment." As required under the Clean Air Act, Pima County had to assess the sources of particulate matter and develop control strategies to reduce particulate emissions. In 1988, following research that showed that smaller particles pose a greater threat than the larger particles, the EPA revised the NAAQS, changing the emphasis to particles with a diameter less than or equal to 10 micrometers, or PM_{10}. When the NAAQS for particulate matter changed from TSP to PM_{10}, based on data from a report by Engineering-Science entitled PM_{10} Emissions Inventory Data for the Maricopa and Pima Planning Areas, Pima County was designated as "unclassified" with respect to PM_{10}. By being designated as "unclassified," Pima County must continue to maintain control strategies for particulate matter emissions.

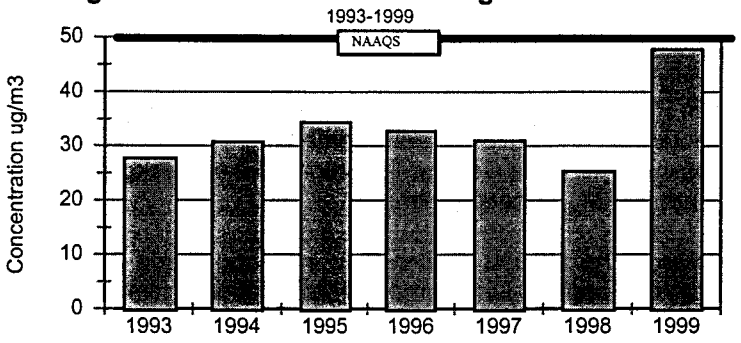
In 1999 the Tucson area had levels of the PM_{10} concentrations that exceeded the federal 24-hour standard several times. In fact, Pima County violated the federal standards by recording exceedances of the standard on four separate days in 1999.

This NAAQS were further revised in 1997. While standards for PM_{10} are still promulgated, very fine particles, with diameters less than 2.5 microns, or $PM_{2.5}$, are the focus of the revised standard. The EPA found that more effective and efficient protection could be provided by establishing separate standards for coarse and fine particles because their characteristics, sources, and potential health effects are very different.

The annual average levels of $PM_{2.5}$ remain well below the federal standard, and the monthly maximum $PM_{2.5}$ levels in 1999 were also, in general, well below the standards. The annual average levels of PM_{10} generally remain below the federal standard; however, several exceedances occurred in 1999. Please refer to Figure 2-6.

Figure 2-6

Orange Grove PM10 Annual Averages



Source: PDEQ's 1999 Air Quality Summary Report

Figure 2-6 illustrates the annual average PM_{10} readings for the Orange Grove monitoring location from 1993 to 1999.

The 1999 violation would ordinarily require the Pima County area to be designated as being in nonattainment of the federal standard. However, by demonstrating to the EPA and ADEQ conclusively that these events were caused by unusually high wind events, Pima County has utilized provisions in the Clean Air Act that will allow the region to remain in attainment of the standards. These provisions call for the development of a comprehensive plan to protect public health and welfare from future high wind natural events, to be called the Natural Events Action Plan (NEAP). The NEAP, prepared by PDEQ in conjunction with ADEQ, was submitted to the EPA June 23, 2001.

Nationally, there has been 25-percent decrease in the average of annual mean PM_{10} concentrations measured at 929 monitoring sites across the country between 1989 and 1998. The national downward trend in PM_{10} annual means is apparent, with a leveling off of the trend occurring in the later years.

Lead

Lead is a highly toxic metal that produces a range of adverse health effects particularly in young children. Lead can cause nervous system damage and digestive problems, and some lead-containing chemicals cause cancer. Lead can also harm wildlife.

Lead has been phased out of gasoline, which has considerably reduced the contamination of air by lead. However, lead can still be inhaled or ingested from other sources. The sources for lead include paint (for houses and cars), smelters, manufacture of lead batteries, fishing lures, certain parts of bullets, some ceramic ware, mini-blinds, water pipes, and a few hair dye products. Stationary sources of lead emissions include nonferrous and ferrous smelters and battery manufacturers.

Monitoring for lead was discontinued in Pima County in 1997, after PDEQ received permission for exemption from lead monitoring by EPA. Pima County's negligible lead levels are due in large part to the elimination of lead in gasoline and the lack of any significant stationary point source of lead emissions. Pima County's negligible lead levels track with national trends. Nationally, between 1979 and 1998, ambient concentrations of lead declined 96 percent, as a result of the phase-out of leaded gasoline.

Nitrogen Oxide (NO_x)

Nitrogen Oxide is a major contributor to smog and acid rain. Nitrogen oxides are produced from burning fossil fuels. Fuel combustion generates nitrogen dioxide (NO_2) and nitric oxide (NO), which is rapidly oxidized to NO_2. Nitrogen dioxide (NO_2) is a poisonous and highly reactive gas. It reacts in the

presence of sunlight and VOCs to form ozone, and contributes through atmospheric reactions to the formation of nitrous and nitric acid aerosols, which result in acid rain. Acid rain can harm vegetation and run into lakes and rivers, which changes the chemistry of the water, and makes it potentially uninhabitable for all but acid-tolerant bacteria. NO_2 can also limit visibility and increase urban haze. Motor vehicles are a major source of NO_2 in Pima County.

While the EPA has defined standards for nitrogen dioxide, concern for nitrogen oxides in eastern Pima County focus on its role as an ozone precursor. Nitrogen dioxide can also play a part in limiting visibility and urban haze.

Nationally, annual mean NO_2 concentrations have decreased approximately 25 percent since 1979. Annual mean NO_2 concentrations declined in the early 1980s, were relatively unchanged during the mid-to-late 1980s, and resumed their decline in the 1990s.

Sulfur Dioxide (SO_2)

Sulfur Dioxide is an odorless gas at low concentrations, but can have a very strong smell at high concentrations. Sulfur Dioxide gas is formed during the combustion of sulfur-containing fossil fuel (coal and oil), during power production, metal smelting, paper manufacturing, food preparation, and other industrial processes. Some industrial processes, such as production of paper and smelting of metals, produce sulfur dioxide. In the past, the major source of SO_2 was copper smelters. A reduction in the number of smelters and technological improvements in pollution controls have substantially reduced these emissions. It is an important contributor to acid aerosols and "acid rain."

As it is with nitrogen oxides, SO_2 is a major contributor to smog and acid rain. SO_2 is closely related to sulfuric acid, a strong acid. It can harm vegetation and metals and can cause lung problems, including breathing problems and permanent damage to lungs.

Sulfur Dioxide Trends

Tucson has no significant sources of SO_2 and the levels continue to be extremely low -- below 10 percent of the federal standards. Significant sources in the past have been the nearby copper smelters but with improved technology and reduced number of operating smelters the emissions have decreased substantially.

Until the mid-1980s, the SO_2 NAAQS was exceeded at sites near nonferrous metal smelters in Arizona, including in Ajo, which is in western Pima County. During the last 10 years, several smelters, including the Ajo smelter, have ceased operations. The Ajo area is designated as an $S0_2$ non-attainment area. Pima County is in the process of working with the EPA to change that designation.

The national 1998 composite average SO_2 annual mean concentration is 53 percent lower than 1979. The national composite average of SO_2 annual mean concentrations decreased 39 percent between 1989 and 1998, with the largest single-year reduction (16 percent) occurring between 1994 and 1995. The trend has since leveled off, declining only two percent from 1997 to 1998. The national reductions from 1994 to1995 in ambient concentrations of SO_2 are due mainly to implementation of the Acid Rain Program, part of the 1990 Clean Air Act.

Air Toxics

Air Toxics, or Hazardous Air Pollutants (HAPs) are generally defined as those pollutants that are known or suspected to cause serious health problems, specifically, volatile organic chemicals (VOC), pesticides, herbicides, metals, and radio nuclides. These chemicals can cause serious health and environmental effects, including cancer, birth defects, nervous system problems, and death. The 1984 release of methyl isocyanate at a pesticide-manufacturing plant in Bhopal, India, killed approximately 4,000 people and injured more than 200,000.

Air toxics are also released from small stationary sources such as dry cleaners and auto paint shops, and large stationary sources such as chemical factories and incinerators. Gasoline contains toxic compounds that escape from liquid gasoline and form a vapor that is released into the air if special controls are not present at the pump. In addition, when motor vehicles burn gasoline, HAPS are emitted from the tailpipes.

The Clean Air Act provided the EPA with the authority to regulate air toxics. Until 1990, the agency listed and regulated seven air toxics. The 1990 Clear Air Act expanded that list to include 189 HAPS to be regulated on the basis of potential health and/or environmental hazard. Pima County does not currently monitor air toxics.

Other Pollutants

Carbon Dioxide (CO_2) is the principal greenhouse gas emitted as a result of human activity (e.g., burning of coal, oil, and gas). If inhaled, it can be toxic in high concentrations, causing an increase in the breathing rate, unconsciousness, and death.

Chlorofluorocarbons (CFCs) are chemicals used in great quantities in industry, for refrigeration and air conditioning, and in consumer products. CFCs, when released into the air, rise into the stratosphere (a layer of atmosphere high above the Earth). In the stratosphere, CFCs take part in chemical reactions that result in reduction of the stratospheric ozone layer, which protects the Earth's surface from the sun. Reducing the release of CFC emissions and eliminating the production and use of ozone-destroying chemicals is very important to the Earth's stratosphere.

Volatile Organic Compounds (VOCs) are organic chemicals synthesized by chemists in laboratories that produce vapors easily. At room temperature vapors readily escape from volatile liquid chemicals. VOCs include gasoline, industrial chemicals such as benzene, and solvents such as toluene and xylene. VOCs are released from burning fuel, such as gasoline, wood, coal, and natural gas. Vehicle emissions are an important source of VOCs. Many VOCs are considered air toxics. VOCs are of concern in Pima County because of their role in the formation of ozone.

Plant life is also a potentially significant source of VOCs, estimated by UA investigators to account for up to one-third of the ozone precursors in the region. These plant sources of VOCs are termed "biogenic" sources, as opposed to anthropogenic (man-made). According to the Ozone Modeling Assessment Study (OMAS) prepared for the PAG by Andrew C. Comrie, isoprene and monoterpenes are usually regarded as the predominant VOCs emitted by plants. Alex Guenther of the National Center for Atmospheric Research has identified that the top isoprene emitters are Australian pine, eucalyptus, sweetgum, aspen, oak, and spruce; the top monoterpene emitters are spruce, fir, Douglas fir, acacia, and pine; the top emitters of other VOCs are spruce, fir, Douglas fir, western red cedar, and orford cedar. Most crops have negligible VOC emission rates.

As explained in the OMAS study, the emission of biogenic VOC is highly dependent on leaf temperature and light intensity. In general, all VOC emission rates increase exponentially with increasing leaf temperature. Consequently, as opposed to anthropogenic emissions which are correlated closely with peak motor vehicle traffic time, biogenic emissions tend to peak in the early afternoon.

Biogenic sources of VOC and prevailing wind directions could account for the high ozone readings being recorded at the Saguaro National Park (East).

CHAPTER THREE

IMPACTS

The following discussion provides a glimpse into air pollution's impacts to humans and the ecosystem. The body of knowledge documenting the effects of air pollution on humans and the ecosystem is increasing. The following is not intended to be a comprehensive review, and much of the research is ongoing. It is intended, however, to underscore how important air quality is to human health and in the protection of our natural resources.

Human Health

The NAAQS are established based on health-based criteria, with particular concern for those populations at potentially higher risk for adverse outcomes from exposure to the criteria pollutants. These at risk populations were defined as having a significantly higher probability of developing a condition, illness or other abnormal status. They include the elderly because of lowered respiratory function, and children and adults with respiratory conditions such as chronic bronchitis, emphysema and asthma.

Asthma is a chronic disease characterized by inflammation of the airways and lungs, which causes attacks characterized by wheezing and shortness of breath. Asthma is of particular concern because of the increased incidences of 1) asthma in children, 2) growing numbers of hospital visits and 3) increased death rates associated with asthma.

According to the Center for Disease Control (CDC), asthma is the most common chronic illness in childhood. In the United States, asthma affects an estimated 14 -15 million persons. The CDC reports that among children 5 -14 years, the asthma death rate nearly doubled from 1980 to 1993. For persons aged 15 - 24 years, the asthma death rate doubled from 1980 to 1993. The CDC reports that among persons aged 0 - 24 years, the annual hospitalization rate for asthma increased 28%. According to the Sierra Club, from 1982 to 1996, the number of children suffering from asthma increased by 55%. The Sierra Club reports that asthma is the number one condition causing absenteeism in school children and is the highest ranked cause of pediatric hospitalizations in the U.S.

Asthma is aggravated by ambient air pollution as well as indoor air contamination. The following is a list of health affects caused by some of the specific pollutant elements discussed earlier. Indoor air has its own hazards and is not discussed here. Many of the pollutants discussed below are associated with specific health risks for asthmatics, but ozone and particulate matter are pollutants of particular concern in eastern Pima County.

Carbon Monoxide (CO)

The fundamental health effect from CO lies in its ability to replace oxygen in the red blood cells, thus reducing the amount of oxygen that can reach body cells. Symptoms of high CO concentrations may include dizziness, slowed reaction times, and headaches. Some evidence, though controversial, suggests acceleration of atherosclerosis. Low-level animal exposures have been associated with abnormal fetal development and increased mortality. In humans, symptoms of low-level exposure begin with headache, fatigue, and flu-like symptoms. Risk groups include smokers and those with coronary artery disease.

Ground-level Ozone (O_3)

Ozone has different health implications in the stratosphere and the troposphere. In the

stratosphere (the 'ozone layer' which is 10-50 km (6-30 miles) above the earth), ozone provides a critical barrier to solar ultraviolet radiation, and protection from skin cancers, cataracts, and serious ecological disruption.

The primary health effect associated with ozone is impaired lung function and irritation of the mucous membranes in the nose and throat which cause coughing and choking. Ozone also aggravates chronic respiratory diseases like asthma and bronchitis. In epidemiologic studies, ozone has been associated with increased incidences of emergency department visits and hospitalizations for asthma and respiratory disease. In addition, the photochemical oxidants that accompany ozone are powerful eye irritants. Animal studies suggest increased susceptibility to bacterial infection. Some evidence supports an association between ambient ozone exposure and increased daily mortality rates.

Ozone induced illness observed in the laboratory includes irritation of the mucous membrane lining the eyeball, upper respiratory irritation, cough, shortness of breath, wheezing, nausea, malaise, and headache. Also associated with ozone pollution is a burning pain below the sternum, which gradually increases in intensity with inspiration and declines during expiration.

Great individual variability exists in ozone responsiveness, ranging from a few individuals suffering clinically important reactions to most persons experiencing mild responses, and the remainder little affected. Persons at risk include persons with asthma or chronic lung disease and those who are active outdoors for prolonged periods, such as children at play, and outdoor workers. Increasing evidence suggests that asthmatics, after exposure to ozone, have increased bronchial reactivity to subsequent allergens. According to Dr. Jefferson Dickey in his book, "No Room to Breath: Air Pollution and Primary Care Medicine", asthmatic children playing outdoors on high ozone air pollution days are roughly 20 to 40% more likely to suffer an asthmatic attack.

Particulate Matter

Health effects of particulate matter are dependent on the size of the particles. Larger particles (greater than 3 micrometers) are deposited in the nasal and tracheobronchial regions, and smaller particles (less than 3 micrometers) penetrate deeper into the lungs. Nearly all particles larger than 10 micrometers are trapped in the upper airways where they tend to be cleared by mucous mechanisms. Studies suggest that smaller particles pose a greater health risk because they can be deposited deeper into the respiratory system. Persons with obstructive pulmonary disease (smokers and asthmatics) experience greater deposition of particles in remote portions of the airway.

Acute symptoms and signs include restricted activity (including days lost from school and work due to respiratory illness), respiratory illnesses, and aggravation of asthma. Clinical observations include declines in lung function, increased asthma medication use, increased emergency department visits, increased hospitalization, increased cardiac and respiratory mortality. Groups at particular risk of acute illness include the elderly and persons with chronic heart and lung diseases. Clinical associations with chronic particulate pollution observed in epidemiologic studies include bronchitis, chronic cough, respiratory illness, asthma exacerbations, decreased longevity, and lung cancer.

In a November 1985 *"Journal of the Air Pollution Control Association"*, 117 households in Tucson were studied for respiratory problems related to indoor and outdoor air quality. The authors of that study believed there to be 'interactive effects' of ozone with outdoor particulate matter that contributed to respiratory impacts with asthmatics.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is absorbed in both large and small airways. Very high concentrations are very dangerous, causing lung injury, fatal pulmonary edema, and broncho pneumonia. A recent report of railroad car accidents resulted in a substantial but unmeasured community exposure. Headache and respiratory symptoms were reported, especially in those with underlying pulmonary disease. Animal studies find increased mortality. In humans, high exposures for 3 hours caused airway inflammation. Low levels have been associated with a significant increase in acute respiratory infections, sore throat, colds and absences from school, and even lower exposures with stuffy nose and cough.

The principal harm caused by NO_2 in Pima County comes from the ozone that it helps to form by reacting with atmospheric oxygen and volatile organic compounds.

Sulfur Dioxide (SO_2)

The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Many types of respiratory diseases such as coughs, colds, asthma and bronchitis are associated with high levels of sulfur dioxide. Children, the elderly, and people with asthma, cardiovascular disease or chronic lung disease (such as bronchitis or emphysema), are most susceptible to adverse health effects associated with exposure to SO_2. At levels that are detectable by smell, SO_2 causes irritation of the eyes, nose, and throat. SO_2 may cause chronic obstructive lung disease after high dose exposure.

Sulfur dioxide reacts in the atmosphere to create H_2SO_4, which forms an acid aerosol. This may be the actual component responsible for many of the health effects observed in epidemiologic studies.

Air Toxics

Air toxics, or hazardous air pollutants (HAPS), can cause cancer, fertility problems, and other very serious illnesses as well as environmental damage. Increasing attention is being paid to the potential for urban air toxics which may aggravate asthma.

Air toxics reach the general population by directly breathing them and by accumulation and concentration in biomass, such as plants and animals, that are subsequently ingested as food (including fresh water fish and human breast milk). Air toxics may cause or promote cancer and other serious health consequences, including respiratory, immune, nervous systems, birth defects, and reproductive effects. Toxics of greatest concern include mercury and other persistent organic pollutants. Some air toxics can cause death or serious injury if accidentally released in large amounts. The 1984 release of methyl isocyanate at a pesticide-manufacturing plant in Bhopal, India, killed approximately 4,000 people and injured more than 200,000.

Air Quality Index

The Air Quality Index (AQI), previously known as the Pollutant Standard Index (PSI), is an index of air quality devised by the Environmental Protection Agency (EPA). It serves as a uniform procedure by which daily air pollution levels are reported to the public. Air quality information is collected by PDEQ monitors located throughout Eastern Pima County. The information is then relayed to the media and the general public using easily understood AQI values.

The Index values represent the percentage of the NAAQS (National Ambient Air Quality

Standards) that the pollutant's measured value falls in. For example, the 1-hour standard for ozone is 0.120 ppm, so a concentration of .084 ppm, which is 70 percent of the standard, would be reported as an AQI of 70.

The AQI qualitative descriptors are good (within the range of 0-50), moderate (within the range of 51-100), unhealthy for sensitive groups (within the range of 101-150), unhealthy (within the range of 151-200), very unhealthy (201-300) and hazardous (301-500). Therefore, in the example cited above, with an AQI of 70, the ground-level ozone level would be considered in the moderate range.

The following tables relate the range of AQI readings with corresponding health effects, for Ozone, Carbon Monoxide, $PM_{2.5}$, and PM_{10}.

Table 3-1: Air Quality Index Carbon Monoxide and Ozone

AQI Category	Ozone						Carbon Monoxide		
	8- hour			1- hour			8-hour		
		Health Effects Statement	Cautionary Statement		Heath Effects Statement	Cautionary Statement		Heath Effects Statement	Cautionary Statement
Good 0-50	0.00-0.064 ppm						0.0-4.4 ppm		
Moderate 51-100	0.065-0.084 ppm	Unusually sensitive individuals may experience respiratory symptoms	Usually sensitive people should consider limiting prolonged outdoor exertion.				4.5-9.4 ppm		
Unhealthy for Sensitive groups 101-150	0.085-0.104 ppm	Increased likelihood of respiratory symptoms and breathing discomfort in active children and adults and people with respiratory disease, such as asthma.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.	0.125-0.164 ppm	Increased likelihood of respiratory symptoms and breathing discomfort in active children and adults and people with respiratory disease , such as asthma.	Active children and adults, and people with respiratory disease, such as asthma, should limit heavy outdoor exertion.	9.5-12.4 ppm	Increased likelihood of reduced exercise tolerance due to increased cardiovascular symptoms, such as chest pains, in people with cardiovascular disease.	People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO, such as heavy traffic.
Unhealthy 151-200	0.105-0.124 ppm	Greater likelihood of respiratory symptoms and breathing difficulty in active children and adults and people with respiratory disease such as asthma; possible respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.	0.165-0.204 ppm	Greater likelihood of respiratory symptoms and breathing difficulty in active children and adults and people with respiratory disease, such as asthma; possible respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid heavy outdoor exertion; everyone else, especially children, should limit heavy outdoor exertion.	12.5-15.4 ppm	Reduced exercise tolerance due to increased cardiovascular symptoms, such as chest pain, in people with cardiovascular disease.	People with cardiovascular disease, such as angina, should limit moderate exertion and avoid sources of CO, such as heavy traffic.
Very Unhealthy 201-300	0.125-0.374 ppm	Increased severe symptoms and impaired breathing likely in sensitive groups; increased likelihood of respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.	0.205-0.404 ppm	Increased severe symptoms and impaired breathing likely in sensitive groups; increased likelihood of respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.	15.5-30.4 ppm	Significant aggravation of cardiovascular symptoms, such as chest pain, in people with cardiovascular disease.	People with cardiovascular disease, such as angina, should avoid exertion and avoid sources of CO, such as heavy traffic.
Hazardous 301-500	0.375-above ppm	Severe respiratory effects and impaired breathing likely in active children and adults and people with respiratory disease, such as asthma; increasingly severe respiratory effects likely in general population.	Everyone should avoid all outdoor exertion.	0.405-above ppm	Severe respiratory effects and impaired breathing likely in active children and adults and people with respiratory disease, such as asthma; increasingly severe respiratory effects likely in general population.	Everyone should avoid all outdoor exertion.	30.5-above ppm	Serious aggravation of cardiovascular symptoms, such as chest pain, in people with cardiovascular disease; impairment of strenuous activities in general population.	People with cardiovascular disease, such as angina, should avoid exertion and sources of CO, such as heavy traffic; everyone else should limit heavy exertion.

Source: U.S. EPA

Table 3-2: Air Quality Index Particulate Matter

AQI Category	Particulate Matter (24-hour)					
	PM2.5			PM10		
		Heath Effects Statement	Cautionary Statement		Heath Effects Statement	Cautionary Statement
Good 0-50	0.0-15.4 ug/m3			0-54 ug/m3		
Moderate 51-100	15.5-40.4 ug/m3			55-154 ug/m3		
Unhealthy for Sensitive groups 101-150	40.5-65.4 ug/m3	Increased likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.	155-254 ug/m3	Increased likelihood of respiratory symptoms and aggravation of lung disease, such as asthma.	People with respiratory disease, such as asthma,. should limit outdoor exertion.
Unhealthy 151-200	65.5-150.4 ug/m3	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should avoid prolonged exertion.	255-354 ug/m3	Increased respiratory symptoms and aggravation of lung disease, such as asthma; possible respiratory effects in general population.	People with respiratory disease should avoid moderate or heavy exertion; everyone else, especially children and the elderly, should limit prolonged exertion.
Very Unhealthy 201-300	150.5-250.4 ug/m3	Significant increase in respiratory symptoms in children and adults, aggravation of heart and lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease , the elderly and children should avoid any outdoor exertion; everyone else should avoid prolonged exertion.	355-424 ug/m3	Significant increase in respiratory symptoms, and aggravation of lung disease.	People with respiratory disease should avoid any outdoor activity; everyone else, especially children and the elderly, should avoid moderate or heavy exertion.
Hazardous 301-500	250.5-above ug/m3	Serious aggravation of heart and lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory and heart disease, the elderly, and children should remain indoors.	425-above ug/m3	Serious risk of respiratory symptoms and aggravation of lung disease, such as asthma; respiratory effects likely in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.

Source: U.S. EPA

Other human impacts

Other human impacts not related to health are regional haze and visibility impairment, odor, and creation of 'urban heat islands'.

Regional Haze and Visibility Impairment

The scenic vistas in Pima County become impaired when light is absorbed, scattered, or extinguished by substances in the air. This impairment can be attributed to natural or man-made sources of air pollution. Two terms that are generally used to describe this view-obscuring phenomenon are: Visibility impairment and regional or urban haze. Visibility impairment means any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions. Regional or urban haze means visibility impairment that is caused by the emission of air pollutants from numerous sources located over a wide geographic area. Such sources include, but are not limited to, major and minor stationary sources, mobile sources, and area sources.

The 1999 ADEQ Visibility Report states that field studies conducted by ADEQ in the Tucson area showed that particles less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$) cause the majority of light scattering and thus lead to reduced visibility. Absorption of light by gases has been found to be minor contributors to the light extinction in the Tucson area as well. Nitrogen dioxide, a pollutant normally present in the area from automobile emissions, absorbs significant quantities of light and also causes reduced visibility. In addition, SO_2 can contribute to limited visibility and increased urban haze.

Meteorological conditions have a significant impact on the presence of visibility-impairing pollutants in the ambient air. High-speed winds disperse pollutants, and stagnant conditions can lead to the accumulation of pollutants in the air. Temperature inversions create very stable conditions, which tend to concentrate visibility impairing pollutants near ground level. Humidity plays a role in observed haze because particulate matter may contain chemical constituents that absorb water, causing an increase in light extinction.

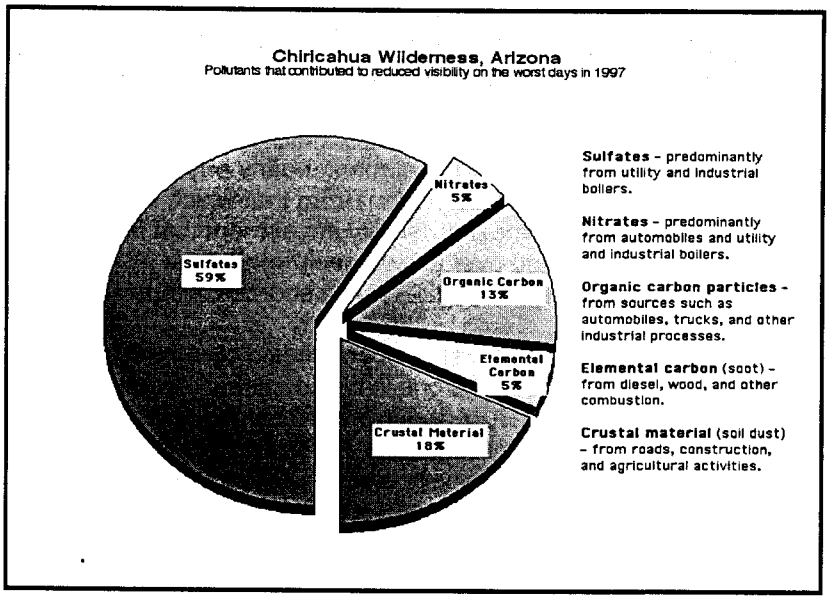
The federal government has promulgated laws to protect visibility in states that contain national parks, such as Arizona. The provisions in these laws mandate that the states prepare an implementation plan to assure that reasonable progress will be made in preventing or remedying existing and future visibility impairment. To comply with federal laws regulating visibility in states with national parks, monitors have been set up in several areas of Arizona, including Pima County. The visibility and urban haze network is part of an ongoing study to measure the chemical composition of Tucson's atmosphere through optical, gaseous, particulate, and meteorological measurements that attempt to explain the nature of the haze and sources that contribute to light extinction.

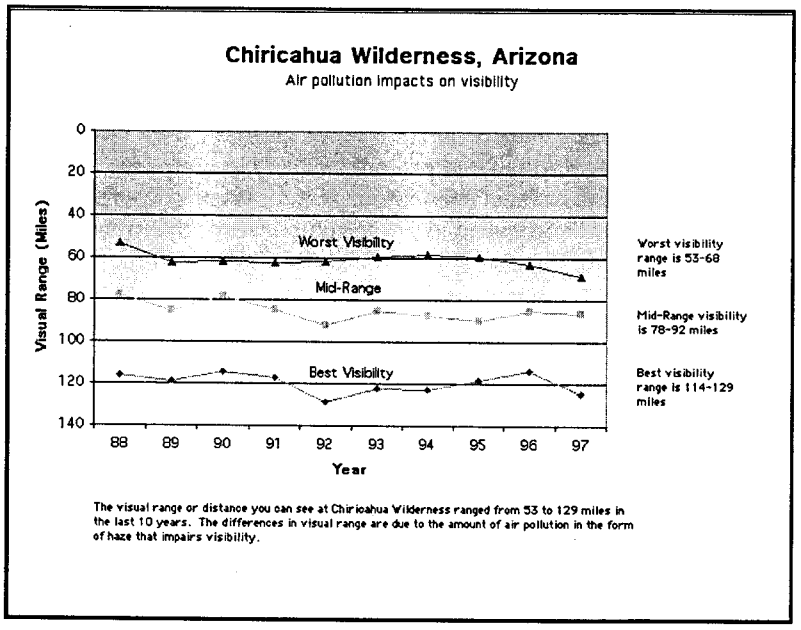
The ADEQ Visibility Report also indicated that light extinction trends remained steady in Tucson as opposed to Phoenix, where it has increased dramatically. Light extinction in the Tucson area is highest in November through January and shows a small weekday-weekend difference with weekend values about 13 percent lower than the average weekday values.

The Tucson area enjoys very close proximity to the Saguaro National Park, National Forest, and wilderness areas. The degradation of air quality and visibility would reduce the natural beauty of these locations, and correspondingly may reduce the number of visitors bringing revenue to Pima County.

Air pollution impacts on visibility is charted below for three natural resources in Arizona: The Grand Canyon National Park, Tonto Wilderness, and Chiricahua wilderness.

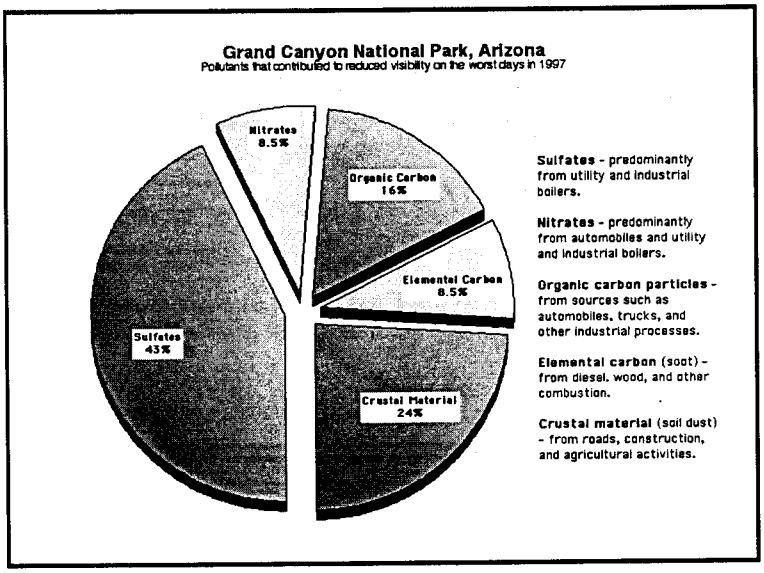
Figure 3-1: Chiricahua Wilderness Arizona Chart
Air Pollution Impact on Visibility

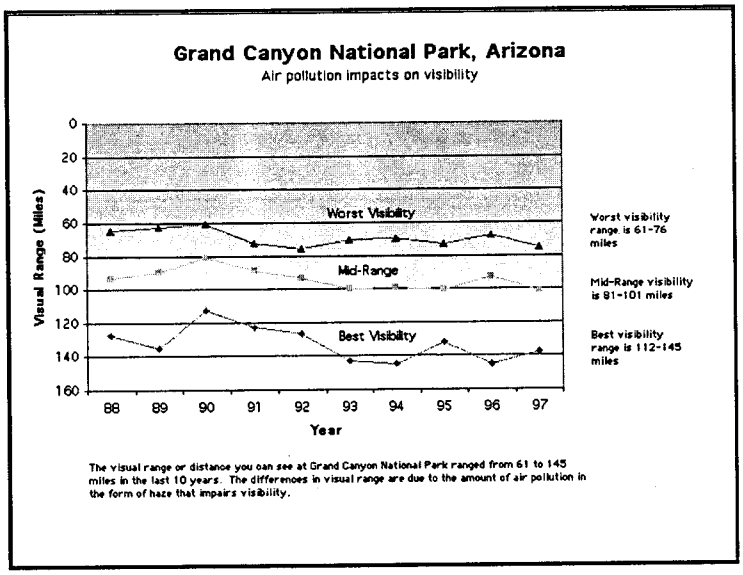




Source: EPA Office of Air & Radiation, Visibility Impairment

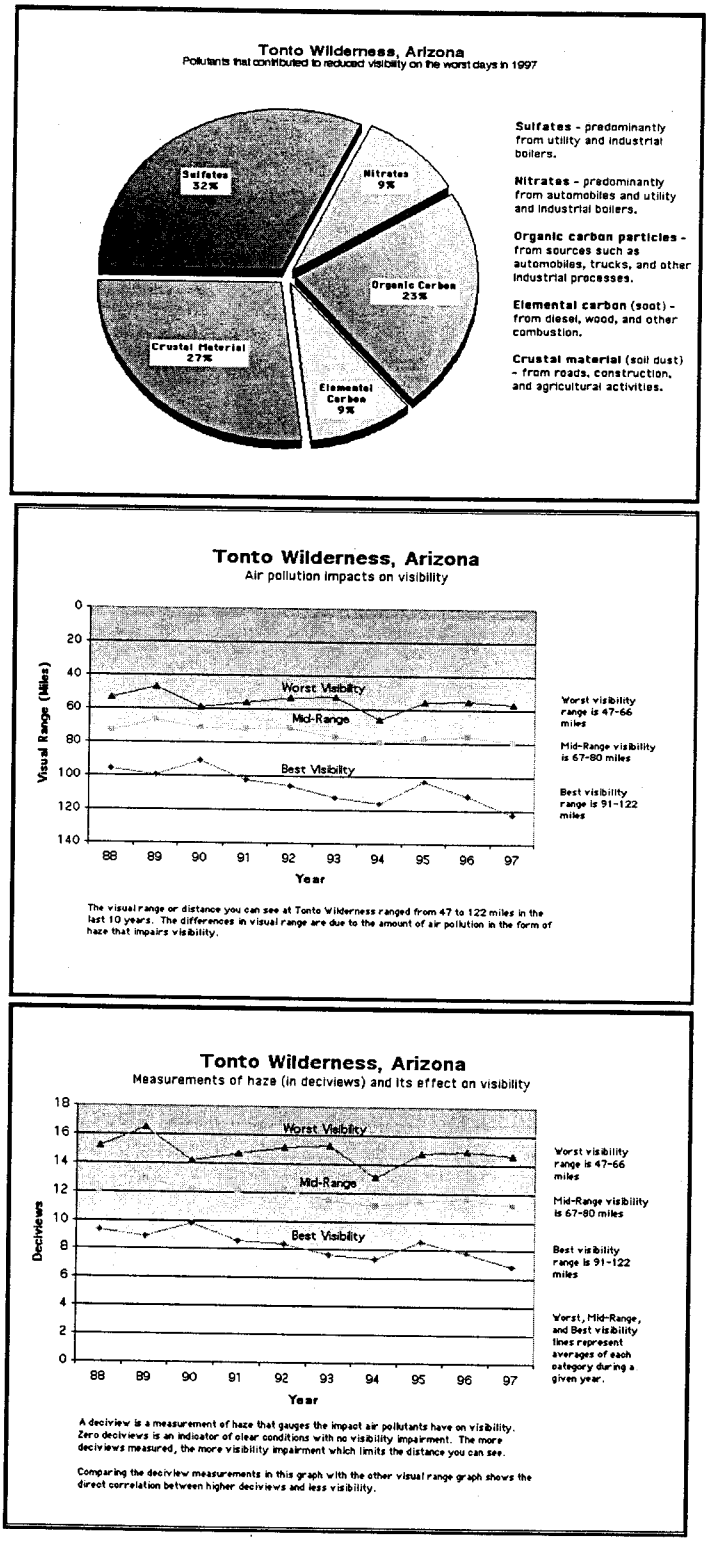
Figure 3-2: Grant Canyon National Park
Air Pollution Impact on Visibility





Source: EPA Office of Air & Radiation, Visibility Impairment

Figure 3-3: Tonto Wilderness Arizona Chart Air Pollution Impact On Visibility



Source: EPA Office of Air & Radiation, Visibility Impairment

As shown by the figures, the visual range or distance you can see at Grand Canyon National Park ranged from 61 to 145 miles in the last 10 years. Visibility ranged from 47 to 122 miles in the Tonto wilderness during the same period of time, while at Chiricahua wilderness, visual range was 53 to 129 miles.

Odor

Odor pollution can be a major cause of discomfort and nuisance and thus affect the well-being and health of human beings. Odors can become a nuisance at levels below health impacts and below permitted values.

Odor complaints from businesses with air quality permits are usually regulated through the permit conditions. The majority of the odor complaints in Pima County are caused by the use of paint products. Other sources of complaints have included fireplaces, motor vehicle exhaust, landfills, tallow plants, and wastewater treatment plants.

Urban Heat Islands

Urban heat islands are created when natural vegetation is replaced by heat-absorbing surfaces such as buildings, parking lots, and streets. Solar energy absorbed into roads and rooftops can cause the surface temperature of urban structures to become 50 - 70 F higher than the ambient air temperatures. As surfaces throughout an entire city become hotter, overall ambient air temperature increases. This phenomenon, known as an 'urban heat island', can raise air temperature in a city by 2 - 8 degrees F.

Urban warming in Tucson, and principally the Urban Heat Island effect, is not new and has been reported as early as 1984. In comparing urban sites to non-urban sites, Andrew C. Comrie ("Mapping a Wind-Modified Urban heat Island in Tucson, Arizona with comments on Integrating Research and Undergraduate Learning"), found that four non-urban sites have warmed an average of 0.026 degrees Celsius per year while two urban sites have warmed at an average of 0.096 degrees Celsius per year. Thus, urban warming has occurred at almost three times the rate of the non-urban warming. This translates to a rise in urban temperature of 2.1 degrees Celsius over 30 years.

The resulting higher temperature caused by the urban heat island has the effect of increasing the demand for cooling energy, which can cost consumers thousands of additional dollars in air conditioning bills. In addition, increased electricity generation by power plants leads to higher emissions of sulfur dioxide, carbon monoxide, nitrous oxides, and suspended particulates, as well as carbon dioxide, a greenhouse gas known to contribute to global warming and climate change. Summer heat islands often accelerate the formation of harmful smog, as ozone precursors such as nitrous oxides (NO_x) and volatile organic compounds (VOCs) combine photochemically to produce ground level ozone.

Scientists have studied both the causes and effects of urban heat islands and have recently begun to identify measures and policies that can effectively cool the metropolitan landscape. These measures include increasing the amount of solar energy reflected by the surfaces such as roofs and pavement, and planting trees. Policies would likely include efforts to specify the use of light-colored materials in roads, building and renovations, zoning for light-colored building materials in commercial areas, strengthen the ability of roads and parks departments to plant new trees and maintain existing ones, and continue to foster community efforts in these areas through volunteer programs. Large-scale mitigation (such as an entire neighborhood or community), have the effect of reducing overall ambient air temperature. Lower ambient temperatures decrease the rates of photochemical reactions associated with air pollution and decrease the need for cooling energy, generating capacity, and, thus, emissions from power plants. All of these have generally positive effects on air quality.

Ecosystem Impacts

Jan Materna writes that, while physiological changes in individual plant reactions can be demonstrated following brief exposures to varied concentration of air pollutants, it is difficult to quantify the effects of air pollution on ecosystems (**Impact of Atmospheric Pollution on Natural Ecosystem by Jan Materna in Air Pollution and plant Life**). Seldom does a single pollutant act alone, and even pollutants from a single source, such as those resulting from burning coal, can have a relatively great variability of individual components.

Air quality can vary over a period of years, by season, and even daily. Variations can also occur during a day due to changes in the temperature stratification between day and night. Pollutant concentrations may vary with the dispersion of air as related to meteorological factors. These variables make a qualitative description of phenomena very difficult.

Therefore, it is not sufficiently meaningful to only measure pollutant concentrations over short intervals of time. The effects of air pollution on ecosystems can be adequately characterized only by following long-term measurements.

Influence Of Air Pollution On Plants

Plants are generally more sensitive to air pollution than animals. Plants use the power of sunlight during photosynthesis to remove carbon dioxide (CO_2) from the air and make sugars, which all animals, including humans, consume. Pollutants can disrupt this basic life process by damaging cells of sensitive plant species. Gaseous pollutants injure sensitive plants by entering leaves during normal gas exchange processes. If injuries to internal leaf systems are severe, they are manifested on leaf surfaces as different patterns of foliar discoloration. Specific pollutants can cause very distinctive patterns that can be used to diagnose the extent and severity of injury. As reported in **Air Pollution Threats to Biological Resources in Saguaro National Monument** by Kenneth Stolte, "When visible foliar injury is severe, other injuries occur such as accelerated aging of the foliage, reduced retention of needles in conifers, reduced growth of roots and shoots, reduced reproduction, altered resistance to predators and pathogens, and increased mortality." He continues by explaining that air pollutants can also affect animals that feed on injured plants. Sugars and amino acids produced in plant leaves may be changed by pollutants, thus altering their nutritional value.

Mr. Stolte states that plants in ecosystems that are in the process of successional transition may be more vulnerable to air pollution than plants in more stable like stages of the same ecosystem. For example, a chaparral plant community recovering from a fire produces many seedlings and resprouts with different leaf structure than plants in older, more decadent chaparral stands. Young, rapidly growing plants with succulent tissue appear to be more vulnerable to pollution than older plants with more sclerophyllous (though) tissue. Air pollutants may differentially affect species of plants growing after a fire and alter the natural processes of community regeneration. Since fire is a natural component of both the mountain and desert ecosystems, the potential exists for air pollutants to alter natural successional processes.

In the Southwest, relatively high levels of sulfur emissions from point sources have occurred for many decades. As with ozone, SO_2 enters plant leaves and causes injury to conifers, broadleaf plants, desert annuals, and shrubs. Some plants, such as lichens, are very sensitive to sulfur dioxide (SO_2). Stolte's book discusses how studies conducted around major point sources such as smelters and power plants indicate that the number of lichen species decreases as one approaches the point source. Vascular and non-vascular plant species and animal species diversity (complex ecosystems) is reduced (simple ecosystems) when chronic air pollution stress is severe.

Carbon dioxide levels are definitely rising, and whether temperatures increase or not, an increase in CO_2 may favor plants that are able to make best use of an increased supply of this important compound. Shifts in the abundance and distribution of plant species could also occur as a result of increased levels of CO_2.

In the Tucson Basin, urbanization induces localized temperature changes known as urban heat islands, with pockets of hot and cold air altering temperature regimes in and near Saguaro National Park. Growth and competition of native plants may be changed by these localized temperature alterations.

Influence of Air Pollution on Soil

Besides the direct influence on the plants and animals in an ecosystem, it is also necessary to consider the influence on soil, especially on its chemistry and biology. The direct influence of pollutants on soil is most significant when the vegetation cover is destroyed. Once the soil has been exposed directly to the pollutants, the major buffering action of the cover is lost. In contrast to the regeneration of damaged vegetation that occurs as air pollution concentrations are reduced, or favorable growth conditions allow an increase of plant vitality, changes in the soil are distinctly cumulative.

The book by Kenneth Stolte then discusses in detail as summarized in the paragraphs below that air pollution has a regional or even sometimes a global distribution, and can be responsible for soil changes over large areas. It can affect soil fertility and pH, and can be directly toxic. The fall-out of heavy metals in some regions in the vicinity of smelters can be very dangerous to the vegetation. The ecological consequences of their accumulation in the soil are serious, for some of them are very persistent in the soil, which makes severe problems for the regeneration of the vegetation cover.

Acidic Precipitation on Soil

Mixing air pollutants with normal precipitation not only adds sulphate, nitrate, ammonia ions, and other chemicals to the precipitation, but the pH of the precipitation is also lowered (made more acidic) in the process. Substantial increases in these ions are occurring as a result of human activity such as the industrialization of our cities and ozone created from the steadily increasing use of smog-producing automobiles. In the Southwest, some summer rain events are acidic, with a pH of 3.6, which is almost as acidic as vinegar. Reports from the 1987 National Atmospheric Deposition Program indicate that Arizona has some of the most acidic rain in the western United States.

The input of substances derived from the combustion of fossil fuels into the ecosystem leads to the formation of sulphuric and nitric acids in water that is present in air, plants, soils, and water bodies. If rain falling on plants is very acidic, the waxy tissue covering the leaf surface can be eaten away; but often the most serious problems to plants originate in the soil. Soil acidification increases over time with the increased production of fossil fuel pollutants. Consequently, aluminum and other undesirable elements may be taken up by plants in excess quantities instead of the calcium, magnesium, and other nutrients they really need. Desirable elements may also be less available due to soil pH changes. Mycorrhizae and soil microbes that are critical in ecosystem functioning can also be destroyed, and the whole system altered. Cactus growth rates can change markedly when pH levels in the soil drop from 6.0 to 5.0 .

The abundance of these elements is increasing to such an extent that the quality of surface water can be influenced and, through this, the fresh water ecosystems and the chemistry of the soil are influenced.

Water Quality

Airborne sulfur and nitrogen compounds damage ecosystems and buildings when they return to earth as acid rain, acid snow, acid mist, acid fog, and/or dry deposition of acid gases and particles. Electric utilities contributed the bulk of SO_2 and NO_x emissions. Largely in response to reports that rain and snow in the northeastern United States had become increasingly acidic, Congress established the Acid Rain Program of the 1990 Clean Air Act Amendments. Following implementation of the program, SO_2 emissions from more than 400 affected electricity generating units (mostly coal-fueled) fell from 15.8 million to 11.9 million tons per year.

Amphibians

The following paragraphs are a summary of an article on amphibians, reported in *The Cold Blooded News*, the newsletter of the Colorado Herpetological Society, Vol 27, #6; June, 2000.

Researchers are examining the roles of disease and air quality in amphibian die-offs that have occurred in the Southwest and around the globe. These die-offs of amphibians are of great concern because amphibians are good barometers of significant environmental changes that may go initially undetected by humans.

Since the 1970's, all seven native true frog species in Arizona have declined to some degree and some precipitously. Introduction of non-native predators or competitors (fishes, bullfrogs and crayfishes) has been the single most important factor in recent declines of native frog populations in the Southwest. Loss and degradation of wetland habitats have also affected many populations. Recent studies implicate Chytrid fungus as a player in the declines as well.

The Chiricahua leopard frog has disappeared from 80 percent of its former habitat. From 1993 to 1996, researchers introduced leopard frogs to new sites where bullfrogs, which are voracious predators on the leopard frogs, were absent. Leopard frogs increased in number exponentially; but in 1997, a rapid, mysterious and alarming die-off of leopard frogs occurred at some of the sites. New research is linking Chytrid fungus as a factor.

Chytrid fungus in amphibians has been implicated in large amphibian die-offs in pristine areas of Panama and Australia. It also was a factor and probable cause of recent die-offs in remaining populations of the endangered boreal toad in the southern Rocky Mountains this year. The discovery in October 1999 of Chytrid fungus in live Tarahumara frogs from northern Mexico implicates disease as a likely factor in those declines as well.

Air pollution is being investigated as to whether it is a stressor that aids the disease's impact. Episodes of frog die-offs at San Bernardino National Wildlife Refuge appear correlated with low-pressure meteorological inversions that trap smelter emissions in the valleys. Air quality, possibly in conjunction with disease, may have been involved in the disappearance of the Tarahumara frog from its last known locality in the United States in 1983. All declining populations of this former Arizona frog were downwind of a copper smelter that produced acid rain and heavy metal deposition in the areas of the frog decline. At the same time, populations of the Chiricahua leopard frog also declined or disappeared at the same localities.

Lichens and mosses

Information obtained for the remainder of this chapter is extracted and/or summarized from "An Investigation of the Impact of Inorganic Air Pollutants on Saguaro National Monument", Proceedings of the Symposium on Research in Saguaro National Monument, by Ernest S. Gladney, Roger W. Ferenbaugh, and Kenneth W. Stolte.

Lichens (Latin, *lichen*, from the Greek word meaning 'tree moss') are unusual organisms because they consist of fungal threads and microscopic green alga living symbiotically and functioning as a single organism. Lichens do not have roots, stems and leaves, so they must receive their nutrients from rainfall which makes them sensitive to pollution. Surface absorption of rainfall is the only means of obtaining vital nutrients that are dissolved in rainwater. Lichens lack protective surfaces that can selectively block out elements, including pollutants, that are dissolved in rainwater. Lichens act like sponges, taking in everything that is dissolved in the rainwater and retaining it.

Similarly, mosses assimilate much of their nutrients and water through their tiny leaves. Unlike the leaves of higher (flowering) plants which have a waxy covering called a cuticle, mosses lack this

protection. This allows mosses to take in water quickly through their leaves during rains or high humidity, and dry out fast when the air dries. This rapid and direct absorption is detrimental when the moisture is laden with pollutants.

Sulfur dioxide (SO_2) is believed to incur the most widespread damage even though it is only one of several air pollution components in the atmosphere. Since there is no means of purging the SO_2, the sulfur content accumulates within the lichen and reaches a level where it breaks down the chlorophyll molecules which are responsible for photosynthesis in the algae. This leads to the death of the fungus. Lichens are also sensitive to fluorides, ozone and particulate matter, which carry trace heavy metals and other toxic compounds.

Lichens are famous for their ability to withstand harsh living conditions; but they are intolerant of atmospheric pollution. They do not thrive in cities or near polluting industries; indeed, they simply disappear.

Saguaro National Park

Intensive research sponsored by the National Park Service at the Rincon Mountain District of Saguaro National Park has focused on pines in the mountains and cacti on the desert floor.

Cacti

In the early 1940's, observations were made that older saguaro cacti in the monument were dying and that reestablishment of saguaro seedlings was not occurring. It is generally agreed that cacti have been declining in portions of the Rincon Mountain District - not only saguaros, but also chain-fruit chollas and barrel cactus.

While epidermal browning of saguaros and spine loss is part of the natural degradation of the epidermis of older cacti, many young plants in the park are also showing browning and spine loss. The root systems of a few brown saguaros that were toppled by wind have indicated that saguaros with epidermal browning may also have poorly developed roots.

The long history of air pollutants within and around the park and the accelerated aging response frequently observed in plants exposed to toxic levels of air pollutants suggest that air pollution may be as a causal or contributing agent in the cactus decline. Researchers are investigating whether air pollution, past or present might be altering the natural resistance of cacti making them more susceptible to freezing, drought, Winthrop, and pathogens.

Air pollution sources such as copper smelters throughout southern Arizona and the growing Tucson metropolitan area date back to the late 19th century. Although emissions from copper smelters have fluctuated with economic conditions, the Tucson area represents a continuously-growing source of urban air pollution. The combined emissions from these sources include particulate matter containing metals and other inorganic compounds, sulfur dioxide, and a variety of organic compounds. Aircraft application of agricultural chemicals in the vicinity of Tucson represents another airborne source of potentially toxic organic compounds.

Air particulate data taken at the Saguaro National Park air quality monitoring station clearly indicates that certain elements are currently enriched in the air particulates coming into the monument. Similarly, several trace elements in the soil samples also indicate anthropogenic impact, probably from dry deposition of air pollutant particulates. There is no clear evidence, however, that this source of trace elemental enrichment of the park ecosystem has had any impact on the biological resources of the monument.

Pines

In the western United States, ponderosa and jeffrey pines are known to be especially sensitive to ozone. Recent growth studies of conifers in central and southern Arizona indicate that many ponderosa pines and douglas-firs (Pseudotsuga menziesii) are not growing as well as their age, climate, and previous (pre-industrial) growth rates would suggest.

Ozone injures these species by destroying chlorophyll and accelerating needle aging. The result is death of lower tree branches and crown thinning. These symptoms have been documented on ponderosa pines in the Rincon Mountain. A survey indicated that 15% of Saguaro National Park pines had been injured by ozone. It is reasonable to assume that if the relatively low cumulative O_3 exposures at Sahuaro National Monument begin to increase, damage to the pines in the monument will also increase.

Other Desert Plants

Seasonal profiles of cumulative ozone exposures in Saguaro National Park that may injure sensitive shrubs are characterized by relatively high ozone exposures occurring in spring and early summer months. High ozone levels sometimes occur during spring months when wildflowers are completing their short growth and reproduction cycles. Some species of desert annuals have been shown to be very vulnerable to ozone.

- Paloverde trees appear to be dying at high rates in some of the same areas as saguaros. Some trees are festooned with mistletoe, but others are not. Stems on trees with mistletoe are starting to turn black. The cause of this is unknown.

CHAPTER FOUR

SOURCES

The previous discussion on air pollutants and trends identified typical sources for specific air pollutants. Table 4-1 summarizes typical source of air pollutants by pollutant. Specific estimates regarding emissions and sources have been periodically developed for Pima County. These emission estimates were determined through a process called an Emissions Inventory. An emissions inventory identifies pollution sources, defines the type of air pollutant and amounts of each emitted from the sources, and determines relative contributions to air pollution in the area. Emissions inventories are compiled using methodologies described in guidelines provided by the EPA.

Data from emissions inventories are used for air quality studies, air quality control strategy development, dispersion modeling, and tracking progress. The last completed emissions inventory was conducted in 1995 by the Pima County Department of Environmental Qaulity (PDEQ); currently, PDEQ and Pima Association of Governments are in the process of developing a detailed emissions inventory for the year 2000.

Figure 4-1 depicts the sources of each major air pollutant based upon the information from PDEQ's 1995 emissions inventory. Reviewing these sources of pollutants, it can be observed that, in general, motor vehicles are associated with many of the pollutants. Emissions from cars, truck and buses have been estimated to make up about 70% of emissions in Pima County.

In the effort to inventory air pollution, it is convenient to categorize sources. Emissions from cars, truck and buses are referred to as "mobile sources." In contrast, there are also "stationary sources," which include plants, mines, etc. A third category is referred to as an "area and fugitive sources." These categories are discussed below.

Stationary Sources

A stationary source is a any building, structure, facility or installation that emits or may emit any air pollutant. Stationary sources are categorized by their emissions. There are three sizes of stationary sources:

"Major" or large sources. These are sources that emit above specific regulatory thresholds in federal law. There are 19 major sources in Pima County. A source may be major for a criteria pollutant or hazardous air pollutants. Table 4-2 lists major sources in Pima County.

"Minor" sources or small source. These are sources that emit pollutants above specific permitting thresholds but below federal "major" source thresholds. There are approximately 250 "minor" sources in Pima County. These sources range from emergency generators who are regulated for CO and NOx emissions to sand and gravel operations, which are regulated for particulate emission

For an emissions inventory, an estimate of emissions of a pollutant from each stationary source may be based on equipment specifications, process rates, stack height, stack diameter, exhaust gas temperature, etc. It may be difficult to estimate emissions from sources that operate on an intermittent schedule, or the amount and types of materials processed fluctuates. In these cases, estimates of emissions may be based on a "typical" operating period. In some cases, the number of employees may be known and an estimate of the potential magnitude of emissions can be made by applying emissions-per employee factors.

Table 4-1
Typical Sources of Air Pollutants by Pollutant

Carbon Monoxide

Primarily is emitted from industrial processes, but the primary source of CO is motor vehicle exhausts. In Pima County, over 70% of the CO in the atmosphere is from motor vehicle exhausts.

Ozone

Ozone is formed in the atmosphere through a complex set of chemical reactions involving VOCs, NOx and sunlight. Typical urban area sources NOx and VOCs are emissions from cars, buses and trucks and off-road mobile sources (such as construction vehicles, planes and trains), power plants and factories.

Particulates

Particulate matter is produced by many sources, including burning of diesel fuels by trucks and buses, fossil fuels, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining, agricultural burning, and operation of fireplaces and wood stoves. The greatest source of particulate matter in Pima County is on-road vehicular travel.

Lead

Lead sources include paint (for houses and cars), smelters, manufacture of lead batteries, fishing lures, certain parts of bullets, some ceramic ware, miniblinds, water pipes, and a few hair dye products. Stationary sources of lead emissions include nonferrous and ferrous smelters, battery manufacturers.

Nitrogen Oxides

Nitrogen Oxides are produced from burning fossil fuels. Motor vehicles are a major source of NO2 in Pima County.

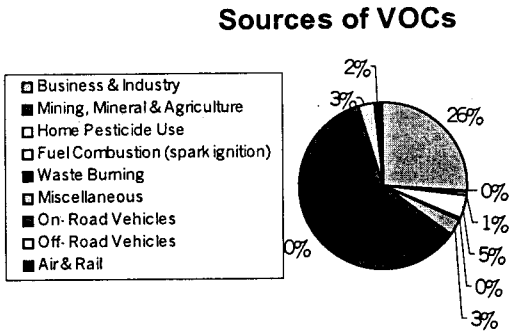
Sulfur Dioxide

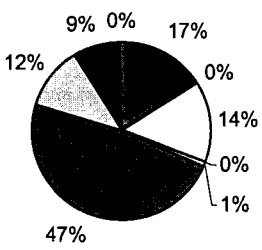
SO_2 gas is formed during the combustion sulfur-containing fossil fuel (coal and oil), during power production, metal smelting, paper manufacturing, food preparation, and other industrial processes. Some industrial processes, such as production of paper and smelting of metals, produce sulfur dioxide.

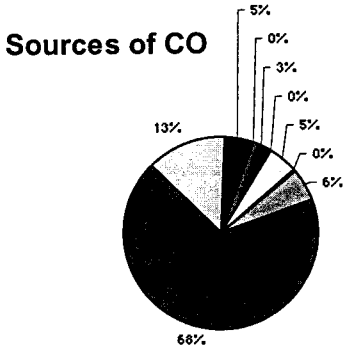
Air Toxics

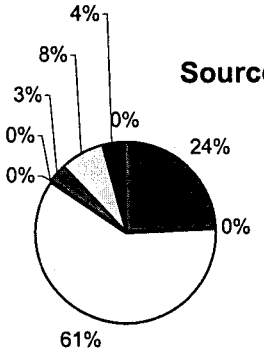
Toxics are released from small stationary sources such as dry cleaners and auto paint shops, and large stationary sources such as chemical factories and incinerators. Gasoline contains toxic chemicals that escape from liquid gasoline and form a vapor that is released into the air, if special controls are not present at the pump. In addition, when motor vehicles burn gasoline, HAPS are emitted from the tailpipes.

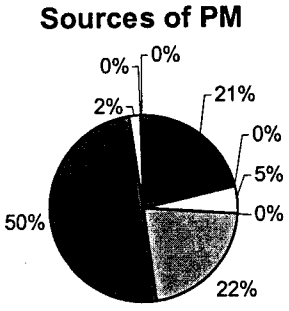
Figure 4-1 Sources of CO, PM, VOCs, No_x, SO_x











Source: PDEQ's 1995 Emission Inventory Report

Table 4-2
Major Sources in Pima County

Company	Pollutants
El Paso Natural Gas	Criteria Pollutants
Southwest Fiberglass	Hazardous Air Pollutants
El Paso Natural Gas	Criteria Pollutants
Learjet, Inc.	Hazardous Air Pollutants
Air Systems Components	Hazardous Air Pollutants
Tucson Electric Power	Criteria Pollutants
Phelps Dodge (Ajo)	Criteria Pollutants
Tucson Electric Power	Criteria Pollutants
Tucson Electric Power	Criteria Pollutants
Santa Fe Pacific Pipeline	Criteria Pollutants
Davis-Monthan AFB	Criteria Pollutants
Chevron USA	Criteria Pollutants
Ina Road Treatment Plant	Criteria Pollutants
Roger Road Treatment Plant	Criteria Pollutants
ASARCO Mission Mine	Criteria Pollutants
University of Arizona	Criteria Pollutants.
Arizona Portland Cement	Criteria Pollutants
The Larson Company	Hazardous Air Pollutants
Los Reales Landfill	Criteria Pollutants

From: Pima County Department of Environmental Quality
Air Quality Permit Files, 2001

Area and Fugitive Sources

This category of source include those that are particularly difficult to quantify – particulate emissions from paved and unpaved roads, dust generated from cleared areas and construction activities, haze generated by controlled burns.

"Area" sources are very small sources that emit pollutants in concentrations that individually may not be significant but, because of the number of similar sources, may in aggregate, impact air quality. Area sources include retail gasoline stations which emit HAPS and criteria pollutants, roadway construction projects which emit particulate matter, and small print shops which emit VOCs. Fugitive sources are emissions do not pass through a stack, for example, particulate matter from unpaved roads, dust from tilling operations. Meteorology frequently plays a role with fugitive emission sources.

For the case of agriculture and construction-related particulate emissions, estimates of emissions can be based on aerial photographs demonstrating land use and EPA emissions factors. Mobile entrained fugitive emissions (paved and unpaved roads) and particulate emissions from brakes, tires and exhaust, may be based upon traffic projections and locally generated emission factors from previous studies.

Mobile Sources

The single largest source of air pollution in the region comes from mobile sources – that is, cars, trucks, buses, trains and airplanes. Emissions from these sources, including particulate matter that is taken up into the air, account for an estimated 70 percent of the air pollution in this region.

These mobile sources account for 86% of total carbon monoxide emissions, 52% of particulate matter, 65% of volatile organic carbons, and 68% of Nox. Compared to 1988 values, the contribution of air pollution by automobiles is increasing for all the mentioned pollutants, except carbon monoxide. In 1988, CO was estimated to be generated 90% by automobile, particulate matter 58% ; VOCs 57% , and NOX 51% . The decrease in CO emissions by automobiles is reflective of the decommissioning of older vehicles. The increase in all the other mentioned pollutants is reflective of the increase in vehicle miles traveled by residents in Pima County.

Formulations of emission factors used in determining air pollution contributions from mobile sources is based on rather complex used in conjunction with data from laboratory testing of representative groups of motor vehicles. Vehicle testing is performed with a "chassis dynamometer," which determines the exhaust emissions of a vehicle as a function of a specified ambient temperature and humidity, speed and load cycle. Based on results from this set of vehicle emissions data, a computer model has been developed to calculate emissions factors for specified speeds, temperatures and trip profiles. The models used to estimate mobile source emissions have been developed primarily by EPA; California has its own model. (Source: Rethinking the Ozone Problem in urban and Regional Air Pollution (1992), Commission on Geosciences, Environment and Resources.)

Regional Transportation Planning and Air Quality Conformity

According to Pima Association of Government (PAG), over the last 20 years, population in the metropolitan area increased 61%, from about 520,000 in 1980 to 853,000 in 2000, while demand for travel, measured in daily vehicle miles traveled or VMT, increased approximately 144%, from 7.2 million miles in 1980 to 17.7 million miles in 2000. The PAG long-range transportation plan projects total daily travel for year 2025 to be more than 35 million miles. The increase in vehicle travel corresponds to increases in vehicular emissions.

Having frequently violated federal standards for CO in the 1970s, the Tucson region was designated by the as a "nonattainment area" for CO. Because of this designation, PAG was responsible for assessing whether the roadway capacity improvements proposed in the 20-year transportation plan would cause the region to exceed CO emissions thresholds dictated by the region's air quality plan. Conformity with air quality thresholds was determined from daily vehicle travel characteristics determined by the travel demand model of future 20-year roadway system, and assumptions regarding the composition of the region's future vehicle fleet. Similarly, the 5-year, short-range Transportation Improvement Program (TIP) was required to conform to the region's air quality plan to assure compliance with clean air standards before the adoption of the program and project development can begin.

No violations of the CO NAAQS have been recorded since 1984, and CO is not currently considered to be a health threat in the Tucson region. On July 10, 2000, the Tucson air planning area was officially redesignated as an "attainment area" for CO. A maintenance plan was approved by the EPA that sets forth the procedures and contingency measures that will be implemented in response to a probable or actual violation of the CO standard in the future. Approval of the CO Limited Maintenance Plan removes the transportation air quality conformity determination requirement. Today, air quality modeling of regional CO is conducted only for comparative purposes.

Based on projected daily travel for year 2025, an assumption of oxygenated fuel level of 1.8%, and enhanced vehicle inspection and maintenance program, the regional carbon monoxide emissions is estimated to be 506.6 tons per day in 2025. These modeled results serve as a guide to the region for future air quality planning, as compliance under the Limited Maintenance Plan is determined by continued expanded monitoring of the existing system.

If the Tucson region were to violate the federal standards for ozone (which may be likely based on study conducted recently by PAG and PDEQ) or any other criteria pollutant, regional transportation planning, both the long range plan and the 5-year TIP, would be required to undergo analyses determining whether the plans promote motor-vehicle travel to a degree that air quality standards would continue to be violated. It is in the best interest of the residents of Pima County to avoid violations of federal air quality standards to avoid the increased costs associated with violations. It is in the best interests of the residents of Pima County to understand the extraordinary contribution by motor-vehicles to air pollution in the region, and to implement effective, realistic alternatives to single-occupant vehicle travel.

CHAPTER FIVE

AIR QUALITY PROGRAMS

The federal Clean Air Act is the law that regulates state and local ambient air quality. It was first passed in 1970 and has been modified several times over the years including a major revision in 1990. Although the 1990 Clean Air Act is a federal law covering the entire country, the states and local agencies do much of the work to carry out the Act. States also have the ability to delegate some of their authority to local governments.

Under the Clean Air Act, the United States Environmental Protection Agency (EPA) sets limits on the concentrations of common air pollutants in the outdoor air anywhere in the United States. This ensures that all residents of the United States have the same basic health and environmental protections. The law allows individual states to have stronger pollution controls, but states are not allowed to have weaker pollution controls than those set for the whole country.

States, in general, are required to develop state implementation plans (SIP) that detail how the state will maintain or reduce emissions to meet the National Ambient Air Quality Standards (NAAQS), and protect public health. A SIP is a collection of regulations the state will use to clean up polluted areas. The state is required to involve the public, through hearings and opportunities to comment in the development of each state implementation plan. The EPA must approve each SIP, and if a SIP isn't acceptable, the EPA can take over enforcing the Clean Air Act in that state by issuing a federal implementation plan (FIP). Regions within states that have exceeded air pollution limits set by the federal government are classified as being in non-attainment of the federal standard.

One of the major breakthroughs in the 1990 Clean Air Act is a permit program for larger stationary sources of air pollution. Under this provision, permits are issued by states or, by county governments. These permits include information on which pollutants are being released, how much may be released, what kinds of steps the source must take to reduce pollution and monitor emissions. Businesses seeking permits have to pay permit fees which help pay the costs of air pollution control activities such as monitoring, compliance assistance, and enforcement.

Within Arizona, these federal mandates are completed by several agencies. Below is a brief discussion of the primary agencies currently involved in air quality planning and implementation in Pima County.

The Role of the Arizona Department of Environmental Quality (ADEQ)

The Arizona Department of Environmental Quality (ADEQ) has the primary authority in the state of Arizona for air pollution control and abatement. ADEQ is charged with:

- Maintaining a SIP that provides for enforcement of the NAAQS and protection of visibility as required by the Clean Air Act;
- Adopting rules with respect to compliance with and attainment of the NAAQS; and
- Assuring that regional air quality plans are implemented.

ADEQ has jurisdiction over portable, mobile and some stationary air pollution sources and is responsible for development of stationary sources permitting procedures and standards (though ADEQ may delegate authority to a county for implementing air pollution control statutes). ADEQ is also responsible for;

- Providing technical assistance to political subdivisions of the State for implementing air pollution control programs;
- Conducting research on the amounts of hazardous air pollutants in the air and their impacts on human health;
- Managing and implementing programs under the Air Quality Fee Fund including the regional Travel Reduction Program and the Voluntary No-Drive Days (Clean Air) Program;
- Implementing the Vehicle Emissions & Inspection Programs; and
- Conducting research on vehicular emissions and clean burning fuels.

The Role of the Pima County Department of Environmental Quality (PDEQ)

The Pima County Department of Environmental Quality (PDEQ) is the local air pollution control agency for Pima County. PDEQ has jurisdiction over air pollution sources not under state jurisdiction. PDEQ is delegated authority from the State of Arizona to regulate certain stationary sources and portable air pollution sources, and also to operate the Voluntary No-Drive Days (Clean Air) Program and other air pollution reduction programs. PDEQ is responsible for monitoring the ambient air quality of the region by collecting and analyzing air quality data.

Within PDEQ, the Director is designated as the Air Pollution Control Officer and has the authority to enforce certain regulations and implement air pollution reduction and maintenance plans.

The Role of the Pima Association of Governments (PAG)

Pima Association of Governments (PAG) is a non-profit Arizona corporation with a governing board composed of elected officials from six jurisdictions. PAG has been designated by the Governor of Arizona as the lead air planning organization for Pima County and addresses regional air quality issues in keeping with federal, state, and local requirements. PAG, together with the State, is responsible for determining which elements of the state implementation plans will be planned, implemented, and enforced by State and local governments. Failure to meet the requirements set forth by federal regulations can result in economic sanctions and/or civil lawsuits. PAG is responsible for the development of air pollution reduction and maintenance area plans, for implementing the PAG Travel Reduction and RideShare Programs, and for making transportation/air quality conformity determinations.

Air Pollution Control Programs

Air pollution control programs can generally be divided into categories of programs for stationary and mobile sources. Stationary source controls are usually monitored and enforced using a permitting program. Mobile source programs are implemented by monitoring mobile sources emissions, and by use of regional programs to encourage reduced operation of mobile air pollution sources. Motor vehicles are the major contributors to the primary air pollutants found in our community: carbon monoxide; particulate matter; and the precursors to ground-level ozone. As a result, transportation control measures are the predominant strategies used to improve air quality in Pima County. In general, control measures that reduce traffic congestion, also reduce the concentration of air pollutants.

Air Quality Permitting Program

The 1990 Clean Air Act is a permit program for larger stationary sources of air pollution. Under this provision, permits are issued by states or, if delegated the authority by the state, county governments.

These permits include information on which pollutants are being released, how much may be released, what kinds of steps the source must take to reduce pollution and monitor emissions. Businesses seeking permits have to pay permit fees which help pay the costs of air pollution control activities such as monitoring, compliance assistance, and enforcement.

Federal Motor Vehicle Emissions Control Program

The federal government has reduced the level of tailpipe emissions allowable to manufacturers of on-road vehicles dramatically over the last ten years. The standards have recently been extended to heavy-duty vehicles and may continue to become more stringent in the future. This tailpipe emissions control program continues to be the most effective control measure for carbon monoxide.

Arizona Vehicle Emissions Inspection Program (VEIP)

ADEQ oversees the VEIP in the state required to have this program. The primary purpose of the VEIP is to identify vehicles on an annual basis that do not meet state emissions standards. Vehicles that do not pass the emissions test are required to be repaired and re-inspected. By requiring regular maintenance of the vehicles, the VEIP is the basic tool to maintain the long-term benefits of the federal tailpipe emissions control program. A one-time waiver for the life of the vehicle is granted for vehicles that have been repaired as required, but still fail the re-inspection.

Arizona Oxyfuels Program

In Pima County oxygenated fuel is required from October 1 through March 31 for gasoline-fueled vehicles. In recent years, the predominant oxygenate used has been ethanol. The use of methyl tertiary butyl ether (MTBE) has been discontinued, due to its persistence as a contaminant of groundwater. The Oxyfuels Program was implemented in 1990 to reduce carbon monoxide levels in Pima County.

PAG Travel Reduction Program

The Travel Reduction Program (TRP) was created in 1988 when Pima County, the Cities of Tucson and South Tucson, and the Towns of Marana and Oro Valley each passed TRP Ordinances. The Town of Sahuarita passed their ordinance in 1996 to join the Travel Reduction Program.

The Purpose of the TRP is to improve regional air quality and reduce traffic congestion by encouraging the use of alternate modes of transportation such as carpooling, taking the bus, bicycling, and walking by employees of local major employers. In addition, the TRP promotes alternative fuel vehicles, modified work schedules, and telecommuting. All employers with 100 or more full-time employees at a single site are required to participate in the TRP. TRP benefits are based on the number of vehicle miles not driven, gallons of gasoline not used, dollars saved and reduction in tons of air pollution produced.

Pima County Voluntary No-Drive Days (Clean Air) Program

Since 1989, the state-mandated PDEQ Clean Air Program has been promoting various clean air strategies to encourage the general public to take actions to reduce air pollution. These strategies include providing K-12 classroom presentations and air quality curricula packets, teacher trainings, speakers bureau, smoking vehicle hotline, public education and community outreaches, and sponsoring or co-sponsoring annual events such as the Car Care Clinic, Bike Fest, Walk Our Kids to School Day, the Clean Air Challenge, Earth Day, and more.

Pima County Voluntary Vehicle Repair and Retrofit Program (V2R2)

In 1999, PDEQ began implementing the state-mandated V2R2 program to address highly polluting older

vehicles. Under this program, owners of vehicles 12 years of age or older that fail the state emissions test, may receive financial assistance to repair the vehicle to pass the test. Based on emissions tests before and after the V2R2 repairs, the average reduction in vehicle tailpipe emissions is approximately 80 percent.

Pima County Voluntary Lawn and Garden Equipment Collection Program

Since 1998, the PDEQ has held a state-mandated voluntary collection of high-polluting gas-powered 2 and 4 stroke motors housed in lawn mowers. The program was expanded in 1999 and 2000 to include other gas-powered gardening equipment such as leaf blowers, string trimmers, chain saws, etc. Individuals who voluntarily dropped off their equipment received vouchers for the purchase of electric or manual equipment.

Mass Transit

Sun Tran provides the fixed route transit service to the Tucson area. A specified fleet size (199 buses) and ridership (14.5 million per year) is required to comply with commitments made by the City of Tucson to help maintain air quality. In addition, Sun Tran has begun conversion of their bus fleet to compressed natural gas (CNG) fuel. By mid-2001, the fleet will be comprised of more than one-half CNG buses. Most of the service is within the City of Tucson (92%), but it also extends into the county (7%), South Tucson and Oro Valley.

Rideshare Program

The federally-funded RideShare Program was established in 1974 with a mission to promote carpooling and other alternate modes of travel to improve air quality, save energy, and decrease traffic congestion. Locally, the RideShare Program is administered by PAG and distributes materials promoting carpooling and maintains a computerized database of individuals interested in carpooling.

The PAG RideShare Program maintains several special databases including a parent pool to aid in the formation of carpools for transporting children to and from school. In addition, another database is the ou-of-county database that matches people who are interested in carpooling inot or out of Pima County on a regular basis. RideShare produces an annual Bike Map, provides information on telecommuting, and supports and supplements the PAG TRP.

Existing County Air Quality Authority

The Arizona Legislature has provided authority to Arizona's counties to control local air pollution problems. Arizona Revised Statutes Title 49, Chapter 3, Article 3 provides county boards of supervisors the following authorities:

- A county may adopt rules to control the release into the atmosphere of air contaminants originating within its boundaries in order to control air pollution.
- A county may adopt a program for the review, issuance, revision, administration and enforcement of permits for sources not under the jurisdiction of the state or otherwise exempt. County procedures adopted to implement these permit programs and permits required to be obtained under Title V of the Clean Air Act including sources that emit hazardous air pollutants shall be substantially identical to permitting procedures for permits issued by the state.
- A county shall adopt a program for administration and enforcement of the federal hazardous air pollutant program established by the Clean Air Act.

- A county may appoint an advisory committee to advise and consult with the board of supervisors and department on matters relating to administration of authorities granted to the county.

- A county shall appoint an air pollution hearing board. The hearing board considers matters relating to denials of permits, permit revisions or conditional orders and may sustain, modify or reverse the action of the control officer.

- Control officers may issue conditional orders, orders of abatement and take other enforcement actions not inconsistent with state law.

- Persons affected by the actions of the county have a right of appeal and may obtain declaratory relief in superior court in accordance with state law.

- A county shall implement a voluntary program to encourage all drivers within the county to not drive their motor vehicles during certain prescribed days.

- A county shall establish a small business assistance program consistent with the program required under the Clean Air Act.

- A county shall establish and coordinate a voluntary lawn and garden equipment emissions reduction program.

- A county shall operate and administer a voluntary vehicle repair and retrofit program to provide for real and quantifiable emission reduction based on actual emissions testing.

- A county may accept delegated functions, powers and duties of the state.

The Pima County Board of Supervisors, declaring, "that every effort shall be made to identify by source and amount the various types of contaminants in the atmosphere; and . . . that all contaminants emitted from each source originating in Pima County shall be prevented or reduced, irrespective of the proportion that each source contributes to the total air pollution . . . subject to the jurisdictional authority regarding types and sizes of emissions sources defined by Arizona Revised Statutes . . ." has adopted air quality control ordinances codified at Title 17 of the Pima County Code. Title 17 implements the statutory directives found in ARS Title 49, Chapter 3, Article 3.

Limitations on County Authority

The Arizona Legislature has enacted statutes to effectuate the provisions of the Clean Air Act, and by its Declaration of Policy made clear its intent to exercise its police power in a coordinated state-wide program to control present and future sources of emission of air contaminants to the end that air polluting activities of every type shall be regulated in a manner that insures the health, safety and general welfare of all the citizens of the state; protects property values and protects plant and animal life.

In 1994 the Legislature enacted Senate Bill 1384 which prescribes the requirements that must be met before a county may adopt environmental rules or ordinances that, (a) are more stringent than Arizona Revised Statutes, Title 49 or rules adopted pursuant thereto, or, (b) are in lieu of a state program that are as stringent as provisions of Title 49 or rules adopted pursuant thereto.

Prior to enactment of ARS 49-112, under ARS 49-479, a county could adopt such rules as it determines are necessary and feasible to control the release into the atmosphere of air contaminants originating within the territorial limits of the county in order to control air pollution, which rules, shall contain standards at least equal to or more restrictive than those adopted by the director of the Arizona

Department of Environmental Quality. In addition, under ARS 49-480, a county could adopt a program and establish fees for the review, issuance, revision, administration and enforcement of permits for sources within its jurisdiction.

Under ARS 49-112, subsection A, in order for a county to adopt environmental rules or ordinances that are more stringent than, or in addition to, state laws or rules, the county must show that,

1. The rules or ordinances are necessary to address a peculiar local condition; and,

2. There is credible evidence that the rules or ordinances, are either:

    a. Necessary to prevent a significant threat to public health or the environment that results from a peculiar condition and are technically and economically feasible;

    b. Required under federal statute or regulation, or authorized pursuant to an intergovernmental agreement to enforce federal statutes or regulations if the county rules are equivalent to federal statutes or regulations;

3. Any fee or tax adopted under the rules or ordinances will not exceed the reasonable costs of the county to issue or administer that permit or plan approval program.

Under ARS 49-112, subsection B, if a county adopts environmental rules or ordinances in lieu of a state program, any fees adopted by the county for which there are no parallel state fees, must be authorized by law and such fees must not exceed the reasonable costs of the county to issue and administer the permit program.

Air Qaulity and Comprehensive Planning

Growing Smarter

In 1998, legislation, known as the Growing Smarter Act (chapter 204, Laws 1998), was enacted which created an urban growth management scheme which strengthened the public land use planning process, provided for the acquisition and preservation of open spaces and established a program for the continuing study and consideration of pertinent issues relating to public land use policies.

Under Arizona law, prior to enactment of the Growing Smarter legislation, Pima County was required to adopt a Comprehensive Plan outlining long-term uses of all land within the jurisdiction of the county. ARS 11-806, requires that the Pima County Planning and Zoning Commission prepare and recommend to the Board of Supervisors a Comprehensive Plan to conserve the natural resources of Pima County, insure efficient expenditure of public funds, and to promote the health, safety, convenience, and the general welfare of the public. The Comprehensive Plan may include, among other things, studies and recommendations relative to air quality.

The Growing Smarter Act amended ARS 11-821(County plan; definitions),by adding the following six elements, having regional applicability, to the Pima County Comprehensive Plan:

- Land Use Planning Element that designates the proposed general distribution and location and extent of uses of the land for housing, business, industry, agriculture, recreation, education, public buildings and grounds, open space and other categories of public and private uses of land appropriate to Pima County. This element shall include consideration of air quality for all general categories of land use.

- Circulation Planning Element consisting of the general location and extent of existing and proposed freeways, arterial and collector streets, bicycle routes and any other modes of transportation as may be appropriate , all correlated with the Land Use Planning Element.

- Water Resources Planning Element addressing the currently available surface water, groundwater and effluent supplies and an analysis of how the future growth projected in the Pima County Comprehensive Plan will be adequately served by the legally and physically available water supply or a plan to obtain additional necessary water supplies.

- Open Space Acquisition and Preservation Planning Element shall include a comprehensive inventory of open space areas, analysis of forecasted needs, policies for managing and protecting open space areas and implementation strategies to acquire additional open space areas.

- Growth Areas Planning Element identifying those areas, if any, that are particularly suitable for planned multi modal transportation and infrastructure expansion and improvements designed to support a planned concentration of a variety of uses, such as residential, office, commercial, tourism and industrial uses. The mixed-use planning shall include policies and implementation strategies designed to make automobile, transit and other multi modal circulation more efficient, make infrastructure expansion more economical and provide for a rational pattern of land development; conserve significant natural resources and open areas in the growth area and coordinate their location to similar areas outside the growth area's boundaries; and promote the public and private construction of timely and financially sound infrastructure expansion through the use of infrastructure funding and financing planning that is coordinated with development activity.

- Environmental Planning Element containing analysis, policies and strategies to address anticipated effects, if any, of plan elements on air quality. The policies and strategies to be developed shall be designed to have a county-wide applicability and shall not require the production of an additional environmental impact statement or similar analysis beyond the requirements of state or federal law.

- Cost of Development Element that identifies policies and strategies that the county will use to require development to pay is fair share toward the cost of additional public facility needs generated by new development, with appropriate exceptions when in the public interest.

The Growing Smarter Act requires any county whose comprehensive plan was adopted (1) before January 1, 1989, to adopt or amend a plan by December 31, 2001, or (2) on or after January 1, 1989, to amend the plan to include all the applicable *new elements*, if applicable, on or before December 31, 2001.

CHAPTER SIX

STRATEGIES

Air quality will persist as an important issue for the region as the population continues to grow and the metropolitan area continues to expand. Motor vehicles will continue to be the predominant source of air pollution. Air quality improvements won as a result of federal mandates for cleaner-burning fuels and reduced tailpipe emissions will be eroded by increased travel.

The following are strategies for maintaining air quality and tools for preventing violation of federal air quality standards to ensure air in the region continues to meet health standards. The strategies are organized into research activities and control strategies. Funding mechanisms and possible legislative changes are also discussed.

RESEARCH ACTIVITIES

To address the increasing challenges of air quality, the air quality planner's toolbox for assessing and analyzing air pollution must be expanded. The following are research-oriented strategies that have been identified to scientifically expand the knowledge base of air quality conditions and impacts in the region.

Expand Air Quality Monitoring Network

PDEQ operates and maintains an air quality monitoring network, which meets federal requirements, for criteria pollutants in the Tucson metropolitan area. Projected growth in the region and potential future violations dictate continued and expanded monitoring of PDEQ's air quality network. People living in newly developed areas, for example, are concerned about particulate matter pollution. Expanded monitoring information in these areas would improve our understanding of the particulate matter concentrations and possible health impacts from those pollutants.

There is also increasing concern regarding toxic air pollutants. The 1990 amendments to the Clean Air Act significantly expanded EPA's role regulating air toxics. Pima County needs to develop a system for identifying, monitoring and tracking emissions. The first step would be to establish baseline values in Pima County and allow for the tracking of concentrations of these pollutants over time.

The region enjoys a wealth of natural resources, including a world-class National Park. Federal regulations now require restoration of visibility to its natural condition over the next sixty years. Pima County DEQ currently operates eight monitoring sites and a camera site for monitoring urban haze and visibility in the Tucson area. Two of these sites are located in class one areas in the Saguaro National Park east and west. The visibility and urban haze network is made up of many different types of monitors to assure reliable data recovery. Some of the varied instruments include dichot samplers for particulate monitoring, Nephelometers, an Aethelometer and a Transmissometer for light extinction, and a camera for visibility verification. There are also IMPROVED monitors in the class one areas for particulate and speciation monitoring. This large and varied network provides Pima County with very complete urban haze and visibility data.

Enhance Modeling Capabilities

Existing modeling capabilities need to be expanded commensurate with new technology and tools that are being developed. Modeling helps planners understand how baseline conditions may develop over time. Computer models help describe the complex interactions, for example, fluid flow and mixing within the Tucson airshed.

Air Quality Modeling

There are several air quality models available that allow accurate analysis of air pollutants, specifically, how the pollutants are formed, the impact of meteorology on pollutants, how a pollutant mass moves and changes over time, the impacts of different control strategies on pollutant concentration, and how emissions in the future will impact air quality. These types of information are very important in order to allow the county to ensure that air quality values remain below the federal health standard and that appropriate control strategies are developed and implemented in order to effectively and efficiently control emissions.

Land Use Modeling

Most of our air pollution is caused by emissions from cars and trucks, and growth in our region has primarily been accommodated by new land development on the periphery of the urbanized area. The number of vehicle miles traveled is directly related to air pollution emissions from vehicles. The type of land use and the availability of alternative modes of transportation directly influence the number of vehicle miles traveled. Good stewardship of our common resources, air among them, demands that we better understand and explain the links among air quality, transportation and land use so that the air quality impacts of land use decisions can be quantified and explained to elected officials and the public. Accurate modeling will allow the county to evaluate the air quality impact of different land use and development options and will allow the decision-makers to make informed decisions.

Conduct research into the impacts of poor air quality on flora and fauna

National research continues to expand and refine our understanding of the impacts of air quality on human health. Some plants and animals, however, are especially sensitive to poor air quality. As described earlier, researchers are beginning to understand the role of poor air quality in declines of flora and fauna in the region, specifically the Chiricahua leopard frog, saguaros, pines and lichens. This understanding is not complete, and given the uniqueness of the Tucson desert region, and the wealth of natural resources under our protection, the need for expanded research is evident. Ongoing research will provide additional information about the impact of air quality on different species of flora and fauna and will allow the County to adequately protect those species that may be particularly sensitive to air pollution.

Develop an emissions inventory

An emissions inventory provides the baseline for all future projections and research. In order to conduct any analytical work regarding air quality, a technically sound and complete emissions inventory is critical. Such an inventory must provide information about the quantity and type of pollutants emitted by the different sources in the county and how those emissions are projected to change over time. This must include all types of sources, including small industrial sources, roads, home heating and air conditioning, large industrial sources, and on- and off-road mobile sources. Maintenance of the inventory is vital in order to ensure continuing accuracy of air quality information.

Research Effective Outreach Programs

The automobile continues to be No. 1 choice of travel mode in the region, and not coincidentally, the greatest source of air pollution. It is clear that individual choices greatly impact our collective air quality, since people routinely make travel decisions. Continued development and implementation of outreach and education programs is critical to provide people with accurate information about the impact of their choices. Research to determine what messages are effective and the best ways to communicate with the public will guide future outreach and education programs. Statistically significant and scientifically designed surveys are crucial to provide agencies with accurate data for program development.

CONTROL STRATEGIES

Control strategies are discussed that can help keep emissions as low as possible. The bulk of the control strategies are dedicated to transportation-related measures, reflecting the fact that mobile sources (cars, trucks and buses) are the greatest factor in the degradation of air quality.

Market based programs

Market-based emissions trading programs can provide greater cost-effectiveness for air quality emissions controls than traditional command-and-control approaches. Market-based emission trading programs typically limit pollution from stationary sources and provide incentives to adopt cleaner technologies on an accelerated schedule. However, a variety of different approaches can be used, including trading of only a single type of pollutant, trading among different types of pollutants, trading among only certain stationary sources or among mobile and stationary sources.

Coordination with Land Management Agencies

Past management practices on our wild lands has focused on suppressing wildfires, which has contributed to significant increases in the amount of vegetation and its structure. Ironically, this practice actually has increased the potential for wildfire. During this same time, formerly undeveloped lands adjacent to the wild lands have been subdivided and housing has sprung up. Land management agencies are focusing on wildfire risk to life and property. One method of addressing this situation is to conduct prescribed burns under controlled conditions. There is a significant increase in prescribed burns and other fuel management/reduction efforts projected by the public land managers in the area. Wildfires and prescribed burns can contribute significant amounts of many pollutants. In order to protect public health and prevent air quality degradation, it is critical that the land management community plan their fuel management and prescribed fire efforts with air quality regulators in advance. This coordination will allow for impacts from these operations to be mitigated and managed effectively. Smoke management will also allow for nuisance, public health and visibility concerns to be balanced with the need to address the current wild land fuels conditions and wildfire risk.

Landscape Ordinance Provisions

There are two aspects of the landscape ordinance provisions. One is the regulation of lawn equipment, and the other is landscaping provisions to reduce the heat-island effect.

Lawn equipment

The 1990 amendments to the Clean Air Act significantly expanded the non-road category of

engines under regulation. The EPA found that non-road engines had total emissions almost as high as highway engines. In the case of particulate matter, non-road emissions were significantly higher than highway emissions. The EPA does not currently cover gas-powered lawn equipment under its non-road regulations. Local regulations can be developed and enforced to prohibit their use. Leaf-blowers, in particular, are notorious for both the emissions and noise they generate.

Tree planting

Vegetation is effective in reducing the heat-island effect in urbanized areas. Large-scale reductions in the amount of heat energy reflected from surfaces have the effect of reducing overall ambient air temperature, causing further reductions in demand for energy by individual building. Trees shade buildings to directly reduce cooling energy demand by blocking the sun's radiation. Indirectly, trees use solar energy to release moisture into the atmosphere in the form of water vapor, which has an additional cooling effect. In addition, trees sequester carbon and reduce soil erosion and water pollution, as well as provide habitat for wildlife and recreation for urban dwellers. Increasing the amount of trees that are planted in new developments and roadway projects can improve both the scenery and air quality.

Building Code Requirements

Revisions can be made to the building code that can have positive effects on air quality, as discussed below:

Electric vehicle recharge outlets in garages/carports

Recently, significant advances have been realized in the area of alternatively fueled vehicles, especially electric vehicles. Incentives and/or requirements for home-based recharge stations make ownership of an electric vehicle more accessible for those who want one.

Natural gas (only) fireplaces

Combustion of wood products produces significant emissions, many of them readily discernible in terms of odor and haze. Other communities have enacted bans on wood burning fireplaces. The Building Code can stipulate that future installations of fire places be natural gas only, to put a cap on these emissions.

Solar water heaters

The Building Code can require rooftop appurtenances so future homeowners can decide to install a solar water heater without invalidating the warranty for the roof.

Receptacles for Internet/telecommuting

Similar to solar water heaters, Building Code requirements can stipulate installation of wall-mounted receptacles for convenient access to the Internet, to facilitate telecommuting and reduce work-related motor-vehicle trips.

Renewable Energy Sources

Here in the desert Southwest, with 240 sunny days a year, we are uniquely positioned to take advantage of the abundant solar energy as a renewable, sustainable energy supply. Local initiatives, tax credits and demonstration projects can put Pima County at the forefront of

supporting and advancing energy alternatives. Other renewable energy sources could be examined, as well.

Transportation-Related Measures

Because of the significant impact of motor vehicle travel on air quality, many strategies for improving and maintaining air quality center around transportation control measures. Transportation control measures (TCMs) reduce mobile pollutant emissions by addressing fuel and vehicle efficiency, maximizing transportation system capacity, and reducing single-occupancy vehicle trips.

TCMs That Address Fuel and Efficiency:

Voluntary Vehicle Repair and Retrofit

Motor vehicles that are well maintained not only offer better performance, but also produce fewer emissions. Pima County administers the Voluntary Vehicle Repair and Retrofit (V2R2) program. The V2R2 program targets the gross polluters and effectively reduces emissions from those vehicles by providing financial assistance for emission system repairs. The program should be continued and expanded to reach more individuals.

Remote Sensing Technology

Remote sensing devices installed on the roadside can identify high emitting vehicles operating on the roads. These devices can be used to supplement an emission control programs.

Stricter Emission Controls

Vehicle inspection and maintenance (I/M) programs measure emissions from on-road vehicles to ensure that vehicles are not emitting high amounts of air pollution. However, there are different types of I/M programs that measure different pollutants and have different degrees of effectiveness and strictness. These programs should be evaluated for their effectiveness in addressing the changing needs in Pima County, today and in the future.

On-Board Diagnostics

New on-board diagnostic technology is an effective way to monitor vehicle emissions by providing on-board computerized tracking of different emissions information. The driver of the vehicle is then alerted to potential emission control problems and can take appropriate action to fix those problems. In addition, a trained repair technician can assess the information and determine if the vehicle emissions control systems are functioning properly or if repairs are required to keep the vehicle operating within the emission control requirements.

TCMS that Maximize Transportation System Capacity

Signal Synchronization

Regional jurisdictions have been proactive in participating in inter-jurisdictional signal coordination. All traffic signals in the Tucson region will be linked to a central traffic signal control system. When completed, traffic signal progression can cross jurisdictional lines. It is important that the one-half mile spacing between traffic signals be maintained, where possible, to facilitate this centralized coordination of traffic flow.

Intelligent Transportation System (ITS) Improvements

Pima County has been pro-active in implementing new technologies into the transportation system. Further development of ITS technologies, including the Freeway Management System and Arterial Management System, will provide travelers with up-to-the-minute information to help them make decisions regarding the most efficient route and best mode of travel.

TCMS that Reduce Single-Occupancy Vehicle Trips

Transportation control measures currently being utilized in the Tucson air planning area include: the PAG Travel Reduction Program; telecommuting; rideshare; transit; and bicycling.

Physical characteristics and patterns of land development (or urban form) can affect air quality, too, by accommodating alternatives to cars, and also by reducing trip lengths. Disperse, single-use patterns of development make automobile travel a necessity and therefore can contribute to air quality problems. Development patterns that locate jobs, housing and recreation in close proximity to each other can mean shorter and fewer car and truck trips, thus reducing the number of miles traveled and reducing motor vehicle emissions. Developments that provide connectivity between activity centers by means of transit, bicycle facilities and shaded walkways offer people alternatives to driving their cars. These kinds of urban form/transportation patterns can be considered transportation control measures.

A 1998 review of both empirical and simulated studies prepared for the Environmental Protection Agency concluded that urban form can have a measurable effect on travel and emissions within a time frame of 10 to 20 years.

The most significant urban form features that can affect travel activity are discussed briefly below.

Land use mix

By incorporating different land uses (e.g., recreation, housing, employment, shopping) within a development, neighborhood or region, trips tend to be shorter distances and more likely to be conducted by walking or bicycling. Multiple uses encourage pedestrian and transit travel by locating a variety of compatible land uses within walking distance of each other.

Some policies that encourage mixed-use zones are: allowing mixed use within zoning regulations; requiring mixed uses, with certain percentages of residential, public, and commercial uses in target areas; adjusting development impact fee structures or giving tax breaks to encourage mixed use.

Clustering of business and residential developments

This refers to creating development patterns that promote clustering of activities in coordination with highway and transit systems, in order to boost the efficiency of the transportation system by reducing the number of vehicle trips and increasing the number of transit trips.

Concentrated activity centers near residential areas

This strategy encourages pedestrian and transit travel by creating areas of high density mixed development near residential areas that can be more easily linked by a pedestrian, bicycle or transit network. Reducing requirements for setbacks and minimum lot sizes creates a stronger connection between buildings and sidewalks and helps to develop a comfortable pedestrian

environment.

Access Management and Street Connectivity

Arterial routes should be designed to minimize vehicular conflicts and provide smooth, uninterrupted flow of traffic. A connected street system encourages pedestrian and bicycle travel by providing more direct routes between locations, plus it alleviates traffic congestion by providing multiple routes between origins and destinations.

Zoning regulations should require connected, narrower streets, with trees and sidewalks in new development and requiring bicycle lanes and transit stops on larger streets in new development. Traffic-calming devices in new development, e.g., textured paving at crossings, frequent intersections with pedestrian-activated traffic signals, and traffic circles, slow traffic, which makes a more comfortable walking environment.

Infill and densification

A compact urban form reduces the length of vehicle trips. Limiting the distances people have to drive makes bicycling and walking more viable alternatives to the private automobile and can reduce the number of vehicle trips. Higher density development also makes mass transit more economically feasible. Pima County can provide incentives for infill development to minimize travel distances and to encourage the use of alternative modes of transportation.

Infill and densification can be accomplished through a combination of zoning regulations and non-monetary incentives. Some policy examples are: stating densities in terms of square feet of land per dwelling unit, rather than minimum lot size, to encourage clustering; setting minimum densities for residential, retail, and employment generating uses in central areas and around transit; adjusting development impact fee structures to encourage infill and increased density development near transit and activity centers, and to discourage outlying development

Increased density near transit corridors

This strategy encourages higher density development along existing or planned transit corridors. It reduces vehicle trips by encouraging transit travel by increasing development density within walking distance (0.25 to 0.50 miles) of a high capacity transit corridor. Similarly, transit travel can be encouraged by increasing development density within walking distance of high capacity transit stations. This also refers to providing connectivity to transit stops along direct, convenient routes from within residential planned units.

Other Transportation-Related Measures

The following mitigation strategies are not transportation control measures, strictly speaking. They fall, however, within the broad range of measures that address transportation-related emissions.

Road paving

There are numerous unpaved roads throughout Pima County. These roads contribute to particulate matter pollution in two ways. First, these roads allow dust to blow off them, especially during high-wind events. Second, vehicles traveling over these roads generate dust that is entrained in the air and exposes people to elevated particulate matter levels. Unpaved roads can be paved or otherwise stabilized to reduce or eliminate the amount of entrained particulates.

Road maintenance

Paved roads contribute to elevated levels of particulate matter since vehicles traveling over dirty roads kick up dust. Regular sweeping using highly efficient street sweepers and stabilization of road shoulders will reduce particulate matter from being entrained into the ambient air.

Requiring culverts on all drainage-ways and washes can minimize dirt accumulation on roads after storms.

Bike and pedestrian facilities

Construct bike paths as part of the comprehensive bicycle plan for eastern Pima County, including bike paths from residential areas to schools, public facilities, and commercial and business centers. Assure connectivity of major arterial routes, bicycle routes, and pedestrian routes.

Dedication of air quality monitoring sites

Dedication of air quality monitoring sites with easements will support an expanded air quality monitoring system, for collection of data in growing areas and expanded baseline information.

Park-and-Ride policies

Dedication of space for the Park and Ride lots can be required from large subdivisions near transit lines. Smaller subdivisions can be required to dedicate funds for Park-and-Ride lots.

Bike lockers

A land use requirement could require that new schools, public facilities, businesses and commercial centers incorporate bike lockers and even shower facilities, integrated with regional bicycle facilities.

Bus shelter construction policy

Developers should contribute to construction of bus shelters along transit lines.

Parking requirements

Strategies in this area include: reducing minimum parking requirements near transit hubs and for projects providing features that encourage pedestrian, bicycle, and transit activity; setting parking maximums in transit- and pedestrian-oriented areas; and requiring preferential parking for carpools.

REVIEW OF LAND USE PLANS AND RECOMMENDATIONS

How we accommodate the growth in this region has impacts on the efficiency of our transportation system, the number of automobile trips that are generated, the choice of mode, and the length of the trips, and therefore, air quality. Through an accounting of existing land uses and infrastructure on a subregional basis, it can be identified where transportation control measures, including urban form features, may be applied most advantageously.

The discussion that follows reviews existing and approved land uses and suggests urban form and transportation features that might be considered in order to preserve and improve air quality in the region.

Rincon Southeast/Santa Rita Subregion

The Rincon Southeast/Santa Rita Sub area is rich in natural resources, the protection of which would expand significantly. Considerable population growth is expected, as well, for the area known as Rincon Valley, and near platted and unplatted subdivisions located south of Interstate 10, in an area known as Mountain View. Another area where approved land uses suggest growth may occur is the Empirita Ranch. These will be each discussed separately.

Figure 6-1 depicts the subregions used in the following discussion.

Rincon Valley

Two area plans govern the growth in the Rincon Valley: the Rocking K Specific Plan and the Vail Valley Specific Plan. The Rocking K and Vail Valley Specific Plans are located in the Rincon Valley Fee Benefit Area, for which travel characteristics are known. Currently, only 10% of trips remain in the Fee Benefit Area, and trips that leave the Fee Benefit Area average 10 miles in length. Household daily vehicle miles traveled is 99 miles. The major roadway facilities are Houghton Road, Old Spanish Trail, Camino Loma Alta, and Marsh Station Road, all two-lane paved roadways, providing limited connectivity to Interstate 10 and the rest of the Tucson region. The conclusion is that the limited number of services and existing roadway facilities are causing long trips.

In addition to approved Specific Plans, Pima County has identified the Rincon Valley Special Area, for which special site design policies apply. These policies are intended to protect the valley's rural character, discourage strip commercial and protect scenic quality. Among the Rincon Valley Special Area site design policies, are several that support developing land in such a way residences are connected by walking and bicycling facilities to activity centers, thereby potentially discouraging unnecessary automobile trips. These policies are discussed below.

Identity

The policy directs creation of a unique identity for the village and community centers through techniques that promote a pedestrian scale to streetscapes and enhance landscaping and building design. The policy encourages developing a sense of place and emphasizes walking.

Activity Centers

The policies support design of activity centers at nodes that facilitate interior circulation. This policy is intended to discourage strip commercial developments characteristic of automobile-dominated land uses. By providing connectivity to interior properties, walking and biking are encouraged, and the urban form is reflective of that which serves the needs of area residents, instead of simply capturing pass-through traffic.

This policy can be further supported by providing public space at activity nodes, such as a park, school, library, or post office. Additionally, thought should be given to how connectivity is accomplished. Walkways and paths should be public, direct and attractive. Activity centers can be connected to greenways and parks in order to enhance accessibility by alternative modes of travel. Greenways and parks should be public space.

Restoration of Rincon Creek

This policy requires that the developer to designate a 30-foot wide easement adjacent to Rincon Creek for continuous hiking and equestrian trials. Restoration of Rincon Creek can be accomplished in such a manner as to also provide a greenway that enhances connectivity to parks, shopping and residential property.

Multi-Use Path

This policy requires that a multi-use path system be designed along Camino Loma Alta to create a linkage between Rocking K and Vail Valley. Separating the multi-use path from vehicular traffic promotes bicycling to equal parity with motor vehicle traffic, while preserving the rural feel for the roadway. Current engineering guidelines by the American Association of State Highway and Transportation Officials (AASHTO) discourage multi-use paths (side paths) for a number of reasons, among them, that intersections with driveway and local streets pose hazardous crossing situations for path users. In conjunction with the policy directive (below) regarding limiting access points, hazardous crossings by the multi-use path can be minimized. In spite of the side path, bicycling facilities within the roadway cross section (i.e., bike lanes) should be incorporated into any roadway widening of Camino Loma Alta.

Access Management

This policy restricts the number of access points (driveways and intersecting streets) along Camino Loma Alta and Old Spanish Trail. There are very few major roadways through the Rincon Valley area. Camino Loma Alta and Old Spanish Trail are among the few major throughways. Control of access will help maintain traffic flow by reducing the number of turning vehicles and reduce the amount of pollutants emitted by motor vehicles.

Transportation Financing Plan

This policy sets the stage for developing an agreement between Pima County and the individual developers in Rincon Valley for a financing mechanism for transportation improvements in Rincon Valley. Future transportation development impact fees can consider costs of providing transit service within this region.

Additional Mitigation Strategies for Rincon Valley

Urban form features that can affect the number and length of trips, which are not addressed in the above policies, include: density and transit accessibility.

Market demand for larger lot sizes and lower density frustrates the goal of developing a compact urban form. In the Rincon Valley, densities are largely already defined by the land uses already approved for that region.

The distance of Rincon Valley from the urbanized core poses problems for developing transit, because transit operating costs are frequently measured on a cost-per-mile basis. Long routes with few opportunities to pick up and discharge passengers result in routes that do not meet the threshold values for operational effectiveness on a per-mile or per-passenger basis. This problem might be addressed by offering a local circulator that provides shorter trips to the nearest City of Tucson Sun Tran route.

Transit funding will continue to be a problem. A dedicated funding source, such as the half-cent sales tax recommended in the Pima Association of Governments (PAG) 2001-2025 Regional Transportation Plan, would be helpful to implement any new transit service.

It is expected that Houghton Road will be both a local urban route, serving fairly dense residential and commercial development, and a regionally significant connector route. Houghton Road will continue to serve travel demand to and from Interstate 10, Rita Ranch, Saguaro National Park, the UA Science and Technology Park, and Mt. Lemmon. Houghton Road is scheduled for widening, and a major corridor study will soon be undertaken to determine the roadway cross-section and level of access for the future roadway facility.

Tailpipe emissions vary according to the age and maintenance of vehicles, but also by running speed. Typically, smooth-flowing lower speeds translate into lower emissions. Emission rates for idling vehicles are very high. According to EPA mobile emissions models and Dr. John Holtzclaw of the Sierra Club, tailpipe emissions increase dramatically above 60 mph. In order to maintain air quality, speeds for a redesigned Houghton Road should be limited to less than 60 mph. Access control for Houghton Road will be an important consideration, particularly where commercial development is planned. Access control refers to, among other things, limiting the number and spacing of driveways in order to reduce the friction caused by turning vehicles, which has the effect of interrupting traffic flow and increasing vehicle emissions. Grade-separated intersections will also help reduce emissions caused by idling vehicles, and can be considered depending on projected volumes.

High-occupancy vehicle (HOV) lanes or transit lanes should be considered in any planning project for the Houghton Road corridor. Bus facilities for Houghton Road should be considered, in conjunction with urban form features that enhance transit accessibility.

Mountain View

Today, the Mountain View area, south of I-10 in the southeast sector of Pima County, is characterized by lot-splitting of large rural lots. Land use plans show the bulk of the area as low density rural. A specific plan has been developed for the Corona de Tucson, south of Sahuarita Road and abutting the Coronado National Forest. Immediately to the west of Corona de Tucson, existing land use plans call for medium density rural. Ownership of this property is fragmented, and no roads currently reach the area, so development at medium densities is unlikely. Immediately to the west again, the Anacay Plan Amendment recently was granted a rezoning from low density rural to allow 1600 units on 1600 acres. The property is yet unplatted.

Pima County has identified the Mountain View Area as a possible area for instituting development impact fees for transportation improvements. This area is poorly served by transportation facilities. There are many dirt roads and no existing services. Corona de Tucson Specific Plan area and adjacent approved land uses represent potential for development to leapfrog beyond existing transportation facilities. This sort of development produces very long trips outside of the development area, which increases household vehicle miles traveled and attendant motor vehicle exhaust, while discouraging alternative modes of travel.

Sahuarita Corridor will be a significant transportation facility when it is developed, at a location north of the existing Sahuarita Road. The location of the roadway is undetermined at this time, and design and construction is unfunded. Planning documents identify the Sahuarita corridor as a high-speed, access-controlled facility, with grade-separated interchanges. It would become a truck bypass for trucks traveling from the Nogales point of entry to eastern destinations.

As a limited-access facility, with grade-separated interchanges, Sahuarita Corridor will have less impact on air quality as compared to an arterial roadway, because vehicles that are accelerating and particularly those idling at traffic signals tend to contribute most significantly to air pollution. As discussed earlier regarding Houghton Road, tailpipe emissions are shown to increase dramatically at speeds greater than 60 mph. Design of the Sahuarita corridor should not encourage high speeds. In addition, a freeway serving leapfrogging developments reinforces past planning trends of emphasizing the private automobile and low-density land uses that depend on automobile travel. This trend can be mitigated somewhat by provision for high occupancy vehicle (HOV) and transit lanes to encourage carpooling. Park-and-ride lots can be located in conjunction with transit planning and planning of major corridors.

Land Use Planning for Mountain View

Land use planning in the Mountain View area will be difficult as uncontrolled lot splitting continues where very little infrastructure exists. State legislation in the past has lessened standards for subdivisions thereby inadvertently facilitating unwise and costly sprawl. The challenge for this area is to control lot splitting to ensure that development standards are met and that transportation facilities are provided. In terms of urban form, all of the features -- density, mixed uses, transit accessibility, urban design, and regional development patterns -- should be applied to developments within this region in order to reduce the number and vehicle trips.

Leapfrog development like Corona de Tucson Specific Plan and adjacent zonings encourage diffuse land use patterns that discourage trips by modes other than private automobiles and trucks and result in longer trips. It is difficult to achieve efficiency in transportation infrastructure with leapfrog development patterns. Corona de Tucson, however, has the advantage of a Specific Plan, which provides for community activity centers within the development, potentially providing services for the area and allowing trips to be made by walking and bicycling.

Empirita Ranch

Empirita Ranch is a land use approved by older planning processes and is far flung from existing communities and services. The development straddles the Cochise County line. It is immediately east of the proposed Las Cienegas Resource National Conservation Area and located among watercourses that are identified as a High Priority Riparian Protection Areas.

The land use plan does show community activity centers that can provide some of the services required by the residential housing proposed by the land use. Nonetheless, the trips that such a development will encourage will be very long. The additional traffic will slow traffic flows on Interstate 10 and create air quality concerns through a subregion that has a high resource value. The additional trips may accelerate the need for widening I-10 east of Tucson.

Upper Santa Cruz Subregion

Development within this subregion is anticipated to occur along the strip of land around Interstate 19. Development will be bounded by Santa Rita Experimental Range on the east and mining activities to the west. The subregion comprises the existing Green Valley development, the Canoa Ranch Specific Plan, and Las Campañas Specific Plan, the latter which has begun construction. Travel characteristics for the Santa Cruz Valley Fee Benefit Area show fewer trips per household, due to the absence of work trips within the retirement communities. A relatively high percentage of household trips stay within the fee benefit area (21%). There are few large employers. These trends are anticipated to continue with the new developments being planned

and constructed.

Substantial growth is also expected within the Town of Sahuarita, which will have impacts on the transportation infrastructure and regional air quality. Low density, lot- splitting development is expected within unincorporated Pima County, along Sahuarita Road, immediately east of the Town of Sahuarita. In the absence of a Subdivision plan or Specific Plan, it is difficult to control land use patterns to encourage a compact urban form, mixed uses and connectivity that serves transit and other alternative modes of travel.

Currently there is no public transit service available. Because of declining physical abilities, elderly populations will need transit services. Door-to-door service would serve this community best. Additionally, elderly populations will want to be able to walk to shopping, dining and other community activities. It will be important to incorporate connectivity to these activities within the land use plans.

The Arizona Rail Passengers Association has been promoting a high-speed rail corridor along existing Union Pacific rail lines from the Phoenix through Tucson and to Nogales. ADOT undertook this study in 1998. The study recommended an initial phase of minor upgrades to the existing rail line, using conventional diesel-electric locomotives and push-pull style passenger cars. Incremental upgrades, including grade separations and higher operating speeds, would be made as ridership develops and funding becomes available. The final phase would be a partially elevated, exclusive right-of-way, high-speed rail electric passenger service. A high-speed electric rail service would effectively discourage single-occupancy vehicle travel by providing a viable alternative that does not have a negative impact on air quality. With service to Tubac, Nogales and Tucson, rail service along the I-19 corridor has the potential of being well utilized for discretionary travel by the retired populations who will live there.

Southwest Subregion

The Southwest Subregion is a large subregion, the northeastern most portion of which comprises the San Xavier Fee Benefit Area, a mix of mature and newly developing areas. Travel characteristics of the San Xavier Fee Benefit Area are known: 12.5% of the trips generated by households within the San Xavier stay within its boundaries, and the average household generates 62.4 vehicle miles of travel per day.

There are many services and activity areas within the urbanized portion of the southwest subregion. Portions of Kinney Road, Valencia Road, and Ajo Way, are being widened as part of the Pima County HURF Revenue Bond program. There is existing transit service by Sun Tran to the Pascua Yaqui Pueblo, and Pima County operates a Rural Transit Route that serves the Tucson Estates, west of the Tucson Mountains. Within the urbanized area, transit ridership potential is good.

Pygmy owl habitat, the Buenos Aires Wildlife Refuge, and floodplain will limit development in the southwest of the subregion. The Tucson Mountains, however, are an important resource that may be adversely affected by poor air quality, because they are so close to the urbanized area.

Land Uses

Star Valley Specific Plan, north of the San Xavier District of the Tohono O'Odham Nation and west of the Pasqua Yaqui Pueblo, has recently begun construction. Like other specific plans, Star Valley has provisions for activity centers within the development, which will offer the opportunity for shorter trip lengths for residents within the new community.

Pima County's land use plan calls for a regional activity center at Kinney Road/Ajo Way. The continued development and enhancement of trip destinations along S.R. 86/Ajo Way could limit trip lengths. The problems associated with strip commercial developments can be discouraged by land-use planning policies similar to that developed for the Rincon Valley, i.e., creating a unique identity for activity nodes through techniques that promote a pedestrian scale to streetscapes and enhance landscaping and building design. A sense of place can be enhanced through the addition of public space and public investment.

In the vicinity of Three Points, the Diamond Bell Special Area calls for medium intensity development. Also in this area is lot-splitting and wildcat development. With the exception of the commercial activities at Three Points, there is little commercial to serve this growing population.

Leapfrog development represented by the wildcat development and the Diamond Bell community are the kinds of development that should be discouraged because of the negative consequences on air quality. The far-flung development results in long vehicle trips. The low density and long distances from major activities centers makes it unable to support transit service. The dirt roads constructed to gain access to new lot splits poses air quality problems for particulate matter.

Transit service to Tohono O'Odham Nation and Ajo Way will continue to be important service for the County to provide. The proximity to the Sun Tran system, the density of development, and the mix of land uses suggest that transit service can be extended through the urbanized portions with good results.

Tucson Mountains/Avra Valley Subregion

The Tucson Mountains/Avra Valley Subregion is both an area with remarkable natural resources, and an area that has seen significant growth in recent years. It includes the Tucson Mountains Fee Benefit Area, the Silverbell-Tortolita Fee Benefit Area, as well as the non-fee area of Avra Valley.

The Tucson Mountains Fee-Benefit area is almost entirely residential development. Employment, shopping and essential services are located primarily to the east of I-10. Due to the nature of the development patterns, only 7.3% of the trips generated by households stay within the benefit area. On the other hand, this area is compact and is located in relatively close proximity to major trip attractors, such as downtown Tucson the University of Arizona. The average household generates only 45 vehicle miles of travel per day, less than half that generated in the Rincon Valley.

Silverbell-Tortolita Fee Benefit Area on the far northwest side abuts the Ironwood Forest National Monument. It also roughly corresponds with the Rillito non-attainment area for particulate matter. The existing rural development consists of extensive, very low-density residential uses, separated by undeveloped areas, and agricultural uses. In terms of drainage and safety, the existing roads are substandard. Much of the existing roadway infrastructure is not county-maintained.

The dearth of continuous roadways and connectivity of existing roadway facilities will be an issue as the area continues to develop, with implications on air quality. Sandario Road is a major north-south route, however, it does not have a bridge over the Santa Cruz River. In one unfunded 1986 Pima County plan, Sandario Road was a limited access facility. Interstate 10 is a major facility serving the area. Already I-10 slows to almost a halt during the morning peak, increasing emissions of pollutants. Motorists are using Silverbell Road as an alternative route.

Access to Interstate 10 is an issue, and will continue to be an issue, for the residents in the Tucson Mountain area. Twin Peaks Road will become an important east-west route if the Town of Marana is successful in constructing a bridge over the Santa Cruz and a traffic interchange at I-10. Improvements to continuity and connectivity will require interregional coordination with Marana and the State of Arizona.

Properties in Marana recently removed from the floodplain are expected to develop with high densities. Marana is also interested developing a town center around its Town Hall site, which has recently been removed from the floodplain. Town staff has expressed interest in developing mixed uses at a pedestrian scale and consideration given to urban design.

Pima County currently operates the Marana rural transit route, providing transit service to low-density development in the far northwest of the region. Due to the distances involved, the transit route is very long. It is difficult to provide transit service that meets any threshold of cost-effectiveness in areas with such low densities and long distances. Marana operated a fixed-route transit service from the Continental Ranch development to the Northwest Hospital, but it was discontinued recently due to lack of ridership.

Opportunities

The Town of Marana figures into the air-quality mitigation opportunities in the Tucson Mountain/Avra Valley Subregon. To the extent possible, these opportunities should be supported.

The developing Marana Town Center is only one of these opportunities. A Marana Town Center would be a source of goods and services for the low-density development in the far northeastern region, posing shorter trip lengths. High-density residential development and a mixed-use town center with pedestrian-scale urban design features means future trips may be conducted by walking and bicycling. The Marana Town Center can also help support for transit services by serving as a transit hub for the subregion.

The Town of Marana has recently instituted a new development impact fee with revenues dedicated for extension of Twin Peaks Road and provision of a new traffic interchange with I-10. This will relieve congestion on Cortaro Farms Road east of I-10. When coupled with a planned bridge across the Santa Cruz River, this interchange will also relieve congestion on Cortaro Farms west of I-10 and improve access for residents in the Avra Valley/Picture Rocks development west of the Tucson Mountains. The National Park Service has been investigating closing Picture Rocks Road to protect the park resources, but have been unable to do so because of the travel demands by residents of Avra Valley. This new connections can provide the connectivity to allow the Park Service to carry out the closure.

High Speed Rail between Phoenix and Tucson is another excellent opportunity, potentially providing a realistic alternative to sitting in bumper-to-bumper traffic on Interstate 10. Rail service to Marana is being investigated as part of the Marana Master Transportation Plan.

Other opportunities for managing air quality, as the subregion continues to develop, include express transit service on Interstate 10, and HOV lanes on Interstate 10 to encourage carpooling, and the locating of Park-and-Ride lots in proximity to existing major routes.

Land use strategies can be utilized as growth occurs in the subregion, but it will be difficult to change the trend of encouraging private automobile use where densities are so low.

As this subregion includes the former Rillito non-attainment area for particulate matter and the

proposed Ironwood National Monument, special consideration should be given to monitoring particulate matter. Several reasonably available control measures have been implemented already, such as paving roads, and stabilizing the banks of the Santa Cruz River. Particular attention should be given in the future to fugitive dust emissions from agricultural operations and future construction activities. Ambient particulate matter concentrations should continue to be carefully monitored in this subregion.

Northwest Subregion

The Northwest Subregion has seen the most rapid growth in the last 10-15 years. It includes the Canada del Oro Fee Benefit Area, for which travel characteristics are known.

The Canada del Oro Fee Benefit area is diverse and contains a broad mix of development types, including a variety of housing options. The broad mix of employment, shopping and services results in this area having, on average, the shortest average trip length for travel to destinations outside of any benefit area. The average household generates 53.8 vehicle-miles of travel per day. Select corridors within the benefit area (Ina Road, Oracle Road) have high levels of public transportation service, and this is the only benefit area with express transit service to major regional employment centers in downtown, the University of Arizona, and the aeronautics business oriented areas south of Tucson Airport.

The Pima County Bond program has committed the greatest amount of bond dollars to bringing the northwest's existing 2-lane rural roads up the job of transporting the volumes of traffic generated by the people who have moved and do business there. These include Cortaro Farms Road, Orange Grove Road, Thornydale Road, La Canada Drive, River Road and La Cholla Road.
Oracle Road, or State Route 77, is located in this region, and has been identified as one of the major corridors to deserve attention in the next 25 years. Oracle Road is expected to continue in the dual role of being a major urban arterial and principal regional route between Pima County and Pinal County. Rapid growth in and around the Town of Oro Valley, combined with expected growth in Catalina and southern Pinal County, is expected to severely stress the carrying capacity of Oracle Road in the future.

The only grade-separated intersection with the Union Pacific Railroad in the northwest is located at Orange Grove Road. All other intersections are at grade. Rail and road interfaces will continue to be an issue on the northwest side, as will be access to Interstate 10.

A new traffic interchange at Twin Peaks Road and extension of Camino de la Manana on the east side could open up areas to the north for development; however, pygmy owl habitat could be a limiting factor to development in this area.

Strategies

Development in this area has been for higher-income residents, who tend to take more trips, typically by automobile. This trend is expected to continue. Trip characteristics of the Canada del Oro area are encouraging. They suggest that land use development to support transit-oriented development and bicycling and walking could have an impact. Since so much of the region has developed with automobile travel as the assumption, retrofitting existing automobile oriented strip development may be in order to create better connectivity between neighborhoods and schools and shopping.

There are also opportunities for trails along watercourses, significantly, the Canada del Oro. Additionally, the Town of Oro Valley has taken progressive actions in planning for and providing

bicycling facilities. Consistent with the regional bike plan, two-lane roads in the region should be improved with bicycle facilities, to provide connectivity of bike facilities through the subregion.

Coordination with agencies will be necessary for streamlined, effective public transportation. The Town of Oro Valley has an effective route-deviating service (Coyote Run). New service should offer route deviation, smaller buses. Express transit to downtown and UA and employment center. As Oracle Road becomes congested, an HOV lane should be considered.

High-speed rail along the existing rail lines should be supported for the potential to relieve traffic loads between Tucson and Phoenix, to relieve traffic congestion locally, and for the air quality benefits it would provide.

Catalina Foothills Subregion

An increase in growth in trips is expected for the Catalina Foothills, in spite of the fact that the area is largely built out as low-density residential. Travel pressures by growth that has occurred and will continue to occur on the northwest side and the southeast side will put pressure on the Catalina Foothills transportation infrastructure.

The Catalina Foothills Fee Benefit Area is close to many major destinations within the City of Tucson. Therefore, trips generated by households have a relatively shorter distance to travel before they are out of the area. Although 17.9% of trips generated are satisfied within the area, the average household generates only 42.4 vehicle-miles of travel per day, lowest among all benefit areas.

Existing large, undeveloped parcels, such as at Skyline and Campbell Avenue intersection, will pose development issues and potentially increase trips on the existing transportation facilities, like Ina Road, Skyline Road, Orange Grove Road, and Sunrise Drive. The River Road/Rillito River corridor will figure prominently in the future. Connecting Snyder Road between Sabino Canyon and Houghton Road is another corridor that will be examined in the future.

Strategies

Existing commercial development in the Catalina Foothills has been designed for access solely by automobile. As the remaining undeveloped parcels develop, strategies should be employed to enhance their access by walking and bicycling. Siting of commercial structures on the lots should consider access from adjacent, existing residential developments in neighborhood-welcoming ways. A pedestrian scale is important for encouraging travel by walking and bicycling, with many opportunities for seating, shade and optimally, public space.

Provision of transit service should be scheduled with consideration given to efficiently providing transit for work trips into UA and downtown while at the same time serving reverse commute trips for workers at resorts like Ventana Canyon and La Paloma. Transit service must be comfortable and convenient in order to be attractive enough for residents such that it gains adequate ridership. This can be accomplished by utilizing smaller vehicles that are able to deviate from fixed routes, providing door-to-door service. Transit funding will have to be addressed in order to provide this type of service in the Catalina Foothills.

Much of the projected increase in travel through the Catalina Foothills will be travel between the southeast side and the northwest side. A strategy should be limiting signalization on through corridors like Sunrise Drive and River Road to minimize numbers of idling vehicles

FUNDING MECHANISMS

Implementing any of these air quality strategies will require the investment of additional financial resources. State legislation may be required to enable the county to raise the necessary revenues. Other sources require action by the Board of Supervisors. Because implementation activities will be recurring over the long term, such funding should be from source streams having a causal relationship to the quality of the ambient air in Pima County. Future increases in taxes and fees could be linked to motor-vehicle transportation, reflecting the large contribution (70%) of motor vehicles on air pollution in the region. There is a broad range of options available for possible funding sources. The list below briefly describes a few of these options.

Vehicle-Emission Based Fees

ARS 49-543 requires that vehicle owners in Pima County, for new vehicles prior to the sixth registration year after purchase or lease, either have their vehicle inspected pursuant to law or pay a $9.00 in-lieu fee. ARS 41-1516(Clean Air Fund) provides that $2.51 of the $9.00 in-lieu fee is deposited in the Emissions Inspections Fund established in ARS 49-544 to reduce the cost of the Emissions Inspections program.

The projected annual revenues from the in-lieu fees paid in Maricopa and Pima counties are $11.7 million.

House Bill 2538 (Chapter 371, Laws 2001) provides that the Clean Air Fund and the in-lieu fee are repealed from and after June 30, 2003. The measure also provides for a Committee of Reference of the House Environment Committee and the Senate Natural Resources, Agriculture and Environment Committee to evaluate the future of the Clean Air Fund relating to funding sources and types of programs

Other Fees

Air Quality Fee

Under ARS 49-551, every person who is required to register a motor vehicle in Arizona pays, in addition to the registration fee, an annual Air Quality Fee of $1.50 at the time of vehicle registration. The monies collected are deposited in the Air Quality Fund established in 49-551(C). The Air Quality Fund is administered by ADEQ for purposes set out in the statute.

By action of the state legislature and approval of the governor, this fee can be increased to expand air quality programs in the state, and can be considered a potential future funding source.

Driver's License Fee

By action of the state legislature and governor, an additional fee can be authorized for each driver's license issued or renewed in Pima County to pay for future air quality programs.

Construction Equipment Fee

A charge for the sale, lease or rental of new or used construction equipment can be assessed at the Pima County level, upon approval by the Pima County Board of Supervisors.

Taxes

Funding from the General Fund could supplement existing air quality funds. Funding from the General Fund is not an ideal source of funding because of competition with other programs that are sustained by General Funds.

If Pima County pursues a sales tax dedicated for transportation, funding for air quality programs should be included in the package that goes before voters in order to mitigate the increased travel that roadway improvements may generate and also to make the initiative more attractive to more voters.

Grants

PDEQ activities, particularly research, can be funded through grant programs awarded through EPA and other sources.

POSSIBLE LEGISLATIVE CHANGES

There are two primary areas that should be evaluated for possible changes. The first deals with funding and the second is the ability of the county to adopt ordinances affecting air quality.

In order to develop and implement additional air quality rules, it may be necessary to modify the current fee structure and authority. Such modification should be evaluated to appropriately establish a relationship between the source category being regulated and the source of the funds.

While many air quality improvements are possible through thoughtful growth and transportation planning and therefore would not require additional air quality rules or ordinances, other strategies would require additional county ordinances. As mentioned previously, the ability of the county to adopt ordinances to protect air quality in Pima County is limited by ARS 49-112. Specifically, ARS 49-112 provides that a county cannot be more stringent than the state unless the ordinance is necessary to address a peculiar local condition and there is credible evidence that the ordinance is either necessary to prevent a significant threat to public health or the environment or is required under a federal statute or regulation. The ability of the Board of Supervisors to protect human health and the environment from the effects of air pollution under 49-479 is unnecessarily constrained by the imposition of 49-112 requirements. As originally enacted, 49-479 provided that the Board of Supervisors may adopt ordinances it determines are necessary and feasible to control releases of air contaminants into the atmosphere. County Boards of Supervisors are elected, locally accountable governing bodies, and as such are in the best position to make air quality control decisions affecting the community. Moreover, recent enactment of comprehensive administrative procedures applicable to county air quality control provides the public ample opportunity to participate in the ordinance adoption process.

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