Once strategies are considered, their effect on the attainment date can be illustrated by this method. This serves as a demonstration that the strategies will allow the standards to be attained.

OXIDANTS

This method may have an application in the area of photochemical oxidant control, where the average oxidant value is predicted by the usual methods. Once the statistical relation has been calibrated, then the predicted mean concentration is used to determine the maximum. There is a limitation in that the model allows a comparison between two variables rather than the large number needed to consider the complex interaction between pollutants and other conditions. A sophisticated method of grouping the data may resolve this problem.

This would not be a problem at all; one may be able to show a reasonable correlation between the change in average traffic emissions and the change in average oxidant concentrations to produce a new average oxidant concentration for 1982. Then one would proceed as above to determine the associated maximum. Certainly, this method could be used when simple one-to-one relationships have been found or a simple approach is being considered. For example, the well-known relationship betwen the 6:00-9:00 a.m. nonmethane hydrocarbon (NMHC) concentrations and the afternoon oxidant maximum may be even stronger if one correlates the average 6:00-9:00 a.m. NMHC value that occurs during a month with the average oxidant value from that same month. The correlation results from a large number of data sets, where each set represents one month of data. This relationship is used to determine the average oxidant expected due to a reduction in NMHC emissions.

CONCLUSION

This method requires a regional approach to analysis. This is due to the need for numerous data sets for calibration; however, this is not undesirable due to the nature of the transportation planning process, the nature of the air pollution problem, and the need for comprehensive strategies. Specifically, the transportation system is regionwide in approach and considers regional growth and development because air pollution characteristics of one area are not completely independent of those in another area in the same city or air shed. It is recommended that one use all of the data in the region for the calibration of the statistical relationship. By analyzing for each area, one can differentiate between them. For example, resources can be properly allocated, strategies can be formulated that do not inhibit adjacent areas, and existing problem-area boundaries can be redefined where and as needed to ensure the attainment of NAAQS without undue restriction on neighboring community growth and development.

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Analysis of Air Quality Sensitivity to Development Pattern Changes and Growth Levels

George J. Scheuernstuhl and Jeffrey May, Denver Regional Council of Governments

To determine the impact of population and employment distribution changes as well as additional population and employment growth on air quality, regional vehicle kilometers of travel and emissions were obtained for four land-development-pattern scenarios for the year 2000. The scenarios include two activity-center scenarios, a dispersion scenario, and a centralization scenario. A fifth scenario was developed on the basis of additional growth beyond the forecast level. The distribution pattern of population and employment had little or no effect on ambient air quality; the alternative patterns showed little variation. The predicted differences in ambient air quality were less than the potential margin of modeling error. Carbon monoxide levels varied by only 6 percent. The centralization scenario produced the highest concentration, but one that is still 43 percent below the federal standard. Ozone predictions showed even less variation; the range was only 2 percent. Given a regional total, the distribution pattern appears to have little effect on regional air quality. A second result is that, although the absolute level of population has an effect on air pollution levels, these two variables are not directly proportional. A 27 percent increase in population resulted in a 16 percent increase in carbon monoxide emissions but only in an 8 percent increase in predicted maximum ambient concentrations. Large changes in population and employment produced smaller changes in ambient air quality.

Improved air quality is a goal in most metropolitan areas of the country. The Federal Highway Administration (FHWA) and Urban Mass Transportation Administration (UMTA) joint regulations and, more recently, the Clean Air Act Amendments of 1977 have increased the emphasis on transportation efforts to achieve this goal. Unfortunately, most analyses of the application of transportation control strategies have indicated that the amounts that vehicle kilometers of travel and vehicular pollutant emissions can be reduced through the application of such strategies are generally low. Given that the level of impact of the transportation management and control strategies is low, some planners have suggested that massive changes in the urban form and structure will be required to achieve desired reductions in vehicle kilometers of travel and air pollutants. The adopted transportation plan for the Denver region is being reevaluated and revised to meet a number of criteria, one of which is reduction of air pollution. As part of this effort, a sensitivity analysis is being performed. A number of possible urban forms are being used to determine the degree to which vehicle kilometers of travel and, therefore, air pollution can be reduced by changes in land use.

PAST STUDY FINDINGS

Past studies referred to here tend to confirm the assumption that a denser development pattern tends to produce less travel, but they also show that the change in travel patterns is likely to be small. In a case study of the transportation and air shed simulation (TASSIM) air quality model in the Boston metropolitan area (1), increases in the density of urban activities over a base or benchmark condition were found to lead to a reduction in average daily round trips and vehicle kilometers of travel; conversely, decentralization led to increases in both of these indicators of travel. However, shifts in urban development activity of a very large magnitude (up to 20 percent) were found to result in small changes in travel patterns (up to 6 percent). The TASSIM study then concluded that, although centralization reduces aggregate travel activity as measured by statistics such as vehicle kilometers of travel, central travel activity is not reduced enough to improve air quality.

Alan M. Voorhees and Associates came to a similar conclusion in a study conducted in the Baltimore-Washington area (2) in which little significant change in travel patterns was found between alternative development patterns. Another analysis conducted in the Boston area involved 22 alternative development patterns. Large-scale changes in land use were found in existing large urban areas, but they had insignificant impacts on aggregate travel characteristics (3). Average trips, average trip lengths, and the total distance traveled were virtually unchanged in most of the alternatives. Only in a few high-density scenarios did the distance traveled decline somewhat because of increased transit ridership.

As part of the areawide environmental impact statement for Denver waste water facilities (4), the U.S. Environmental Protection Agency (EPA) examined the effects of large-scale changes in emissions distribution (17-25 percent). The analysis indicated that regionwide control of pollutant levels is not achieved by substantial redistribution of emissions. This study found almost no detectable change in ozone (O_3) concentration or distribution.

Zahavi (5) used travel-time budget theory to question the belief that people in compact cities need less motorized travel than do those in dispersed cities because more destinations are within walking distance. He found instead that daily travel distance per automobile is remarkably similar in all cities.

The Cost of Sprawl (6) postulated that vehicle trips could vary by as much as 60 percent between a planned, mixed high-density-development scenario and a sprawl, low-density single-family dwelling scenario (6). This study also postulated that some change in average trip length might occur for nonwork purposes.

SCENARIOS

The objective of the land use and air quality sensitivity analysis was to provide a general indication of the levels of reduction of vehicle kilometers of travel and air pollution emissions that might be expected from some rather extreme changes in land use within the region and from changes in travel patterns and conditions. Thus, a number of development scenarios were selected for testing (7); their composition reflected these extreme conditions and was not intended to suggest actual expected future conditions. The general approach used was to maintain a common transportation system and to maintain an overall population and employment control total. Within this framework, population and employment concentrations were varied to reflect four different growth patterns:

1. An activity-center scenario in which population and employment growth are distributed outside of the urban core area among a number of high-density activity centers,
2. A second activity-center scenario in which employment is concentrated in the activity center but population is distributed in a more dispersed pattern,
3. A dispersion scenario in which population and employment growth are distributed in a uniform dispersed pattern throughout the metropolitan area, and
4. A centralization scenario in which population and employment growth are predominantly concentrated in the urban core area.

In addition to the four growth pattern tests, an accelerated-growth scenario was also tested. This test assumed that the Denver region would grow to a population level 27 percent greater than was assumed in the population level of the year 2000 plan.

Benchmark Condition

The benchmark condition to which the results of the sensitivity analysis were compared consists of the adopted year 2000 regional growth and development plan and the year 2000 restated transportation plan. All of the development scenarios tested use a control total activity level of 2.35 million population and 1.13 million employment. The activity levels represent the current regional policy forecasts for population and employment. The distribution of population and employment for the benchmark condition is in accordance with the distribution pattern approved for use in the plan restatement process. These distributions involve the combination of concentrated activity in the region's central core area, growth concentrations in 11 activity centers and three high-density corridors, and semidispersed low-density growth elsewhere in the metropolitan area.

We decided to use a single, common transportation system (the restated transportation plan) for the sensitivity analysis. We reasoned that a constant transportation system configuration would focus the sensitivity analysis on changes in land use. Further, given the focus of the restated transportation plan as largely that of improvement of the current system, not on extensions nor, for that matter, major deletions of this system, we reasoned that the system would be in place throughout the region despite any major land use configuration changes that might occur through policy decisions over the next 20-50 years.

Land Use Scenarios

Scenarios tested represent abstract extremes of land use patterns, which range from centralization of activity within the central business district (CBD) of the Denver region to a dispersed activity pattern. They are summarized in Table 1.

1. Activity-center scenario 1—The bulk of 1975-2000 population and employment growth (60 percent and 90 percent, respectively) is in 11 activity centers. Only 5 percent and 10 percent of population and employment growth is in the central core (125 000 population and 205 300 employment). Each activity center has the same population and employment in the year 2000 (48 000 and 42 000, respectively).
2. Activity-center scenario 2—Employment is concentrated in 11 activity centers; population is distributed in a dispersed pattern. Ninety percent of 1975-2000 employment growth is in the activity center and 10 percent is in the CBD. Population distribution is same as in the benchmark pattern.
3. Dispersion—Population and employment growth between 1975-2000 will occur in a dispersed pattern; activity centers and the CBD will remain static. All population growth and 95 percent of employment growth will be distributed across the region outside activity centers and the CBD.
4. Centralization scenario—The major share of population growth from 1975-2000 and the majority of employment growth will occur in the CBD; elsewhere densities will be low to moderate. Twenty-five percent of the population growth between 1975-2000 and 60 percent of the employment growth will be allocated to the Denver CBD. This results in extremely high densities [36 250 persons/km^2 (14 000 persons/mile^2) and 41 500 employees/km^2 (16 100 employees/mile^2)]. Current Denver densities are 20 000 persons/km^2 (7700 persons/mile^2) and 20 500 employees/km^2 (7900 employees/mile^2).
5. Growth scenario—An activity level 27 percent higher than was forecast in the benchmark is assumed for 2000. It will be distributed proportionally across the region and follow the benchmark distribution.

PROCEDURES FOR PROCESSING GROWTH AND DEVELOPMENT SCENARIOS

The transportation model used operates on 654 zones and external stations. Trip generation is performed by use of cross-classification techniques for four groups of household income. Trip distribution and modal split are based on logit formulations for single-occupancy automobile trips, shared ride, and transit passengers. Automobile vehicle loading procedures involve the production of three trip tables, one for the morning 2-h peak, a second for the afternoon 2-h peak, and a third for the off-peak hours. The loading procedures reflect capacity restraint in the peak periods and an unconstrained situation in the off-peak.

The air pollution dispersion model was developed by Systems Applications, Inc. (SAI). The air pollution model translates the morning peak, the afternoon peak, and the off-peak roadway volumes and speeds into automobile emissions. The air pollution dispersion model then predicts carbon monoxide (CO) and O_3 air quality levels by time of day by 2.59-km^2 (1-mile^2) grid. The area modeled is approximately 50 × 50 km (30 × 30 miles).

Data processing costs precluded complete model runs for all alternatives. The full modeling process was used to produce the benchmark scenario only. The results of alternative growth pattern and additional growth scenarios were synthesized. First, zonal population and employment data sets were developed, based on the scenario descriptions discussed earlier. These data sets were then used to estimate the total number of trips produced and attracted for each zone. These trips were then compared to the trips generated by use of a similar methodology under the benchmark scenario. The resulting growth factors were then applied to the benchmark scenario trip table. By doing this, special generators (such as parks, military bases, and shopping centers) were automatically included and updated. Trips to and from each zone grew or declined in proportion to population and employment changes. Similarly, trip interchanges were affected as surrounding zones grew or declined, which lengthened or decreased trip lengths. Changes in transit modal share and automobile occupancy rates brought about by population and employment location relative to transportation facilities were also accounted for. For example, as trips to the CBD increased, so did automobile occupancy rates and the transit modal share.

In order to prepare zonal population and employment data sets for the alternative-growth scenarios, a set of operations were defined and applied to current 1975 population, employment, and land use data sets and also to the baseline plan-2000 zonal data set. The algorithms produced year 2000 total population and employment allocations by zone for each scenario. An assumption was made that the alternative scenarios would all have similar household sizes and income distributions. A second assumption was made that retail employment in each zone would vary directly with total employment. The location of regional shopping centers was held constant.

Based on the above information, the numbers of trip ends for each zone were produced. In order to do this, an equation was developed that combines all trip ends, both production and attractions, for all trip purposes. Growth factors used in a FRATAR calculation of trip interchanges were developed by dividing the predicted

Table 1. Distribution of population and employment.

	1975		2000 Benchmark and Growth		2000 Activity Center 1		2000 Activity Center 2		2000 Dispersion		2000 Centralization	
Area	Population (%)	Employment (%)	Population (%)	Employment (%)	Population (%)	Employment (%)	Population (%)	Employment (%)	Population (%)	Employment (%)	Population (%)	Employment (%)
Central core area	6	22	5	17	5	18	5	18	4	16	17	42
11 activity centers	8	12	9	16	22	39	9	39	-	-	-	-
Remainder of study area	72	56	72	56	59	33	72	33	-	-	69	47
Total metropolitan study area	87	90	86	89	87	90	86	90	86	90	86	90
Denver region total	100	100	100	100	100	100	100	100	100	100	100	100

trip ends in each zone by the predicted trip ends found in the baseline year 2000 case. (A FRATAR distribution is a zonal growth distribution model based on the assumption that the change in trips in an interchange is directly proportional to the change in trips in the origin and destination zones contributing to the interchange.)

The growth factors were then applied in FRATAR to the afternoon peak automobile vehicles trip table. The resulting afternoon peak trip table was then loaded onto the plan network by use of capacity restraint. Morning peak and off-peak trip network loads were then synthesized. This was accomplished by holding the relation between the afternoon peak and the morning and off-peak constant between the base case and each of the alternative scenarios. All-day volumes by link were then summarized for input into the air quality dispersion model. Speeds were summarized by roadway functional classification and area type.

The Colorado Department of Highways used the link and speed information to produce a projection of emissions by link for each hour of the day. This emissions file assumed that the automobile emission controls called for in the Clean Air Act Amendments of 1977 would be achieved by the manufacturers. It also assumed that the inspection and maintenance program passed by the Colorado State Legislature would still be in place in the year 2000.

Controls on tailpipe emissions have led to the situation where approximately 50 percent of hydrocarbon (HC) emissions and 25 percent of CO emissions are currently produced merely by turning an automobile on and off (9). These percentages are expected to grow in the future. This cold start-hot soak phenomenon dramatically limits the effectiveness of reduced trip lengths through changes in land use form. The air pollution model used is not truly sensitive to the cold start-hot soak phenomenon. Although the overall emissions rates do include a cold start-hot soak assumption, emissions are calculated based on vehicle kilometers of travel at defined speeds. They do not vary in the SAI model with trip lengths.

IMPACT ON VEHICLE KILOMETERS OF TRAVEL AND SPEEDS

Changes in the vehicle kilometers of travel that resulted from the land development pattern changes are described in Table 2. As shown under the vehicle-kilometers-of-travel change factor column, the growth scenario represents an approximate 21 percent increase in vehicle kilometers of travel, whereas the other scenarios result in 2-3 percent decreases in vehicle kilometers of travel, except for the dispersion scenario, which represents a 4 percent decrease in vehicle kilometers of travel. The lower vehicle kilometers of travel from the dispersion scenario represents an unrealistic situation in which employment is uniformly distributed across a set of zones.

Table 2. Vehicle kilometers of travel and speed summary.

Scenario	Vehicle Kilometers of Travel	Change Factor	Speed (km/h)
Baseline	46 139 000	-	49.1
Activity center 1	44 607 000	0.97	46.7
Activity center 2	45 590 000	0.99	46.7
Dispersion	44 219 000	0.96	50.0
Centralization	45 189 000	0.98	46.8
Growth	55 696 000	0.21	39.3

Note: 1 km = 0.62 mile.

The second factor that affects air pollution emissions is vehicle speed. As given in Table 2, all of the scenarios produce an average speed (weighted by vehicle kilometers of travel) of approximately 45-50 km/h (28-31 mph), except for the high-growth scenario, which results in an average speed of only 39.3 km/h (24.4 mph). As speeds decrease, emissions of CO and HC increase.

Note that the high-growth scenario produces both the highest vehicle kilometers of travel and the lowest speeds, or what we would intuitively expect to be the worst air pollution emission case. The benchmark scenario produces the next highest vehicle kilometers of travel but also produces a relatively high speed. The other scenarios produce indeterminate results that vary little from the benchmark in average speed and vehicle kilometers of travel.

EFFECT OF GROWTH AND DEVELOPMENT ON AMBIENT AIR QUALITY

Table 3 summarizes the predicted ambient air quality for the various growth and development alternatives. The most significant result displayed in this table is the lack of variation in predicted levels of CO and O_3 among the scenarios.

The variation in CO predictions is from 53 percent of the 10.35 mg/m^3 (9 ppm) 8-h standard under the benchmark scenario to 57 percent of the standard under the high-growth scenario. For O_3 the variation is even smaller—from 88 percent of the 234 µg/m^3 (0.12 ppm) standard for the benchmark scenario and upward to 89 percent of the standard under the first activity-center scenario.

The distribution pattern of population and employment appears to have little or no effect on ambient air quality. The predicted differences in ambient air quality are less than the potential margin of modeling error. Thus, the absolute order of growth and employment distribution alternatives is of questionable value. What is important is the extremely small effect of alternative development patterns on air quality. A second result is that, although the absolute level of population has an effect on air pollution levels, the two are not directly proportional. Large changes in population and employment appear to produce propor-

Table 3. Ambient air quality predicted for growth and development alternatives.

	CO		O_3	
Scenario	Predicted 8-h Concentration	Percentage of 10.35 mg/m^3 Standard	Predicted 1-h Concentration	Percentage of 234 µg/m^3 Standard
Baseline	4.8	53	0.105	88
Activity center 1	4.9	54	0.107	89
Activity center 2	4.9	54	0.106	88
Dispersion	4.9	54	0.106	88
Centralization	5.1	57	0.106	88
Growth	5.2	57	0.106	88

Note: 1 mg/m^3 CO = 0.87 ppm; 1 µg/m^3 O_3 = 0.51 x 10^{-3} ppm.

Table 4. Emissions inventory and projections.

		CO Emissions (Mg/day)			HC Emissions (Mg/day)		
Year	Scenario	Vehicle	Total	Total Compared to Benchmark	Vehicle	Total	Total Compared to Benchmark
1976-1978	Existing	2200	2384	4.48	190	224	3.43
2000	Benchmark	295	532	1.00	33	65	1.00
2000	Activity center (population and employment)	293	531	1.00	33	66	1.01
2000	Activity center (employment)	296	533	1.00	33	66	1.01
2000	Dispersal	277	514	0.97	31	63	0.97
2000	Centralization	292	530	0.99	33	66	1.01
2000	Growth	381	627	1.18	44	80	1.22

Note: 1 Mg = 1.1 tons.

tionally smaller changes in ambient air quality.

COMPARISON WITH FEDERAL STANDARDS

The Denver region currently experiences frequent violations of the national ambient air quality standards for CO, O_3, nitrogen dioxide (NO_2), and suspended particulate matter; however, the severity of the violations appears to be steadily decreasing. The federal Clean Air Act of 1960 established ambient air quality standards that allow for an adequate margin of safety for protection of public health. The air quality impacts of the growth and development scenarios were compared against these federal standards for the two pollutants that were examined—CO and O_3. The federal standards below are for the second worst case that occurs annually.

CO

Emissions of air pollutants are generated by a variety of sources. In order to analyze the cause of air pollution in the Denver region and to forecast future ambient air quality levels, we needed to develop an up-to-date inventory of the emission sources for each pollutant. The inventory of current emissions in the Denver region indicates that about 2359 Mg (2600 tons) of CO are released into the air on a typical winter day. Winter, because it is the worst season for CO pollution, is modeled in future year projections.

As given in Table 4, by 2000 regionwide CO emissions are projected to decline by 74-84 percent from current CO emission levels. Note that vehicular sources are calculated to account for 93 percent of current CO emissions; however, this percentage will fall to 55 percent by the year 2000 under the benchmark scenario.

The variation in total emissions is reduced by holding projected nonvehicle emissions constant for the various development scenarios. The assumption is made that the location of population will not affect the number of airplane trips, space heating requirements, or industrial emissions. The variation in total CO emissions is then from 97-116 percent of the benchmark emissions; the dispersion scenario is the lowest and the high-growth scenario is the highest.

The emissions listed in Table 4 were input into the air pollution dispersion model by time of day and geographic area. The result is a decrease in the predicted second maximum CO levels from violation of 22.77 mg/m^3 (19.8 ppm) in 1977 to a prediction of 5.52 mg/m^3 (4.8 ppm) under the benchmark scenario. The two activity-center scenarios as well as the dispersion scenario result in predicted 8-h concentrations of CO of 5.64 mg/m^3 (4.9 ppm) or, effectively, the same as under the benchmark scenario. The centralization and the high-growth scenarios result in slightly higher predicted CO concentrations of 5.87 mg/m^3 (5.1 ppm) and 5.98 mg/m^3 (5.2 ppm), respectively. The range of predicted 8-h CO concentrations is quite small for all scenarios, ranging from 53-57 percent of the 10.35 mg/m^3 (9 ppm) standard.

O_3

The federal standard for O_3 is a 1-h average of 234 $\mu g/m^3$ (0.12 ppm). In 1977 the second highest recorded 1-h average concentration in the Denver region was 304 $\mu g/m^3$ (0.156 ppm), 30 percent higher than the standard.

The inventory of current emissions in the Denver region indicates that for HC (a primary precursor of O_3) nearly 227 Mg (250 tons) are currently emitted on a typical summer day—summer is the time when O_3 levels are at their peak. Vehicular sources currently account for 85 percent of HC emissions. This is predicted to decline to 50 percent by the year 2000 under the benchmark scenario. Over this period of time, total HC emissions (as delineated in Table 4) decline from an existing level of 227 Mg/day to a projected benchmark of 65 Mg/day (72 tons/day) in the year 2000, a decline of approximately 72 percent. The variation in HC emissions over the year 2000 scenarios is 97-122 percent of those generated under the year 2000 base case. The lowest HC emissions are found in the dispersion scenario; the highest are under the high-growth scenario.

Predictions of ambient air quality levels show a decline in projected levels of O_3 over the 22-year time period to the year 2000. O_3 levels will decline from the second worst maximum of 304 $\mu g/m^3$ (0.156 ppm) in 1977 to 205 $\mu g/m^3$ (0.105 ppm) under the benchmark scenario in the year 2000. The various growth and development alternatives show only minor variation from the benchmark scenario. The first activity-center scenario results in the highest predicted O_3 concentrations. Note that the geographic area where 195 $\mu g/m^3$ (0.1 ppm) is exceeded was effectively identical for all of the scenarios and the benchmark.

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Travel and Emissions Impacts of Transportation Control Measures

John F. DiRenzo, Peat, Marwick, Mitchell and Company,
Washington, D.C.

The Clean Air Act Amendments of 1977 and the Transportation-Air Quality Planning Guidelines jointly developed by the U.S. Environmental Protection Agency and the U.S. Department of Transportation require the states and metropolitan planning organizations to prepare revised state implementation plans and conduct air quality alternatives analyses to meet national ambient air quality standards. This paper summarizes basic information developed from a synthesis of literature to assist metropolitan planning organizations and other agencies in meeting the requirements of the planning guidelines. Specifically, the paper (a) identifies transportation control measures for reducing emissions, (b) summarizes the effects on travel and emissions of individual measures and packages of measures, and (c) suggests approaches and issues to be addressed in air quality planning.

This paper summarizes basic information developed from a synthesis of the literature to assist metropolitan planning organizations (MPOs) and other agencies in meeting the requirements of the transportation-air quality guidelines jointly developed by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation (DOT).

The objectives of this paper are

1. To identify transportation control measures for reducing air pollution emissions and meeting national ambient air quality standards (NAAQS),
2. To identify the travel and emissions impacts of individual control measures and packages of measures, and
3. To suggest approaches for selecting, analyzing, and evaluating impacts of transportation system management (TSM) and longer-range control measures.

Virtually all urban areas of the nation of more than 200 000 population currently do not meet NAAQS for photochemical oxidants (O_x). Many of these areas also exceed NAAQS for carbon monoxide (CO). Vehicular travel within these urban areas is a major source of both pollutants.

Transportation-related air quality problems are of two general types: localized and regional (1). Localized transportation-related air quality problems generally cause CO concentrations that exceed either the 1-h or, more likely, the 8-h CO air quality standard. Factors that contribute to this problem include the high vehicular traffic volumes that occur under traffic conditions frequently found in densely developed portions of urban areas.

Regional transportation-related air quality problems are typically caused by vehicular and stationary source hydrocarbon (HC) and nitrogen oxide (NO_x) emissions, which react chemically in the atmosphere to produce O_x pollutants. The chemical reactions that produce oxidants are complex and depend on many factors, such as prevailing meteorological conditions and the topographic, land-use, and industrial characteristics of an urban area (2).

The distinction between CO and O_x pollutants is important in that different control measures are required to effectively address localized, as opposed to regional, air quality problems.