

EXECUTIVE SUMMARY
ASSESSMENT OF MATERIAL DAMAGE AND
SOILING FROM AIR POLLUTION IN THE
SOUTH COAST AIR BASIN

CALIFORNIA AIR RESOURCES
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ABSTRACT

This report describes a study to develop and apply a methodology for estimating some of the costs of air pollution and soiling damage to selected materials in the California's South Coast Air Basin (SCAB). A combination of land use and census data plus field and telephone survey techniques were used to estimate the types and quantities of exposed materials in the SCAB. The total exposed area of materials on structures was estimated at 5.6×12^9 sq. ft. for the SCAB based on census data. Painted wood and painted stucco accounted for 60 percent of the total exposed material.

Published damage functions that relate damage (e.g., corrosion or soiling) to air quality together with geographically distributed air quality measurements were applied to the materials inventory to develop quantitative estimates of pollutant induced materials damage in the SCAB. The total amounts of damage for each material for which there was a damage function were converted to maintenance costs based upon assumptions of use and maintenance.

The monetary cost of increased maintenance from damage to materials caused by the ambient levels of sulfur dioxide, particles, and ozone in the SCAB was estimated to be \$42 million per year. This economic loss was dominated by soiling and erosion of latex paint. This project did not estimate the costs of damage to several important materials found in the SCAB, such as glass and concrete, because air pollution damage functions do not exist for these materials.

ASSESSMENT OF MATERIAL DAMAGE AND SOILING FROM
AIR POLLUTION IN THE SOUTH COAST AIR BASIN

Executive Summary

The purpose of this project is to investigate the monetary loss due to pollutant-caused damage to man-made materials exposed outdoors in the South Coast Air Basin (SCAB) during the period 1978-1980. SCAB includes Los Angeles, Orange, and the adjacent, non-desert portions of San Bernadino and Riverside Counties in California.

In order to determine the costs associated with the damage to materials caused by air pollution, the following information was assembled:

- the distribution of materials exposed outdoors;
- the ambient pollutant levels to which the materials are exposed;
- the rate at which damage is incurred as a function of pollutant levels;
- the amount of damage that triggers remedial actions (i.e., the critical damage levels), or alternatively the frequency of maintenance in polluted atmospheres;
- the costs of remedial or preventive actions.

The distribution of materials was estimated from field and telephone surveys, and from land use and federal census data. The quantities of materials exposed on buildings were approximated for both the residential and commercial-industrial sectors but different approaches were used for each category. For the residential sector, a field survey of 89 single family homes, selected to cover a spectrum of housing ages and median household income levels, was conducted to identify the types and quantities of materials exposed on single family residential properties. The quantities of materials exposed on apartment buildings (multifamily residences) were quantified from detailed maps produced by the Sanborn Map Company. These maps contain structural and surface materials data for most apartment,

commercial, and industrial buildings. The quantities of materials found on mobile homes were based on a previous study done by Atwater, et. al. (1985). Estimates of materials in place for single and multifamily residential properties were based on these data and regression analysis was performed to relate the materials distribution to census variables. These results were then extrapolated basin-wide using the 1980 Census of Housing and Population and the regression equations derived from the field survey results.

The quantities of materials exposed on the commercial-industrial sector were quantified based on a review of Sanborn maps selected to represent each of 16 different land-use categories found in the basin and were extrapolated to all businesses based upon the U.S. Census Bureau's County Business Patterns. A total of 805 buildings in the residential and commercial-industrial categories (including agricultural buildings and public facilities) were analyzed to determine the types and quantities of materials found on buildings in the basin. Table 1 presents the results of the inventory of exposed materials on all of the categories of buildings studied.

In addition to the materials quantified on buildings, materials used for other purposes were also included. Municipalities, corporations and area-wide agencies (such as CALTRANS) responsible for maintenance of materials exposed along highways, railroads, and for maintenance of oil wells, electricity and water distribution systems were contacted. Museums and cemetery associations were surveyed also to determine the distribution of monument stone and bronze sculptures exposed. Substantially less materials were exposed for these uses than were exposed in the residential and commercial-industrial sectors. The amount of materials exposed for non-building uses is also summarized on Table 1.

Other materials were found during the course of the survey, but were not quantified either because minimal air pollution-induced deterioration is

TABLE 1
 SUMMARY OF THE AREA (10⁸ft²) OF MAJOR MATERIALS
 IN SOUTH COAST AIR BASIN

Material	Single	Residential Multifamily	Mobile	Commerical- Industrial	Non-Building Applications	Total
Stucco, Painted	15.73	6.09		.53	.54	22.89
Wood, Painted	10.94	0.30		.37	.21	11.82
Iron				.28		.28
Brick	.72			2.42		3.14
Brick, Painted	.64					.64
Concrete				4.15		4.15
Reinforced Concrete				1.30		1.30
Glass	4.48	1.11	.07	5.46		11.12
Gunite				.01		.01
Steel, Painted				.06	2.40	2.46
Metal Clad			.90	.49		1.39
Tile				.02		.02
Stone	.10					.10
Galvanized				.01	2.64	.01
Total	32.61	7.50	.97	15.06	5.79	61.97

anticipated or because their occurrence was so infrequent that reliable estimates of their total exposed area were not possible. Materials of this category found during the survey include aluminum, plastics, slate, cloth, fiberglass, asbestos shingles, granite and bronze. Pollutant impacts on all of these materials, except cloth and bronze, are probably quite small. Cloth was found only as awnings on a few buildings and reliable extrapolations of total area were not possible. Bronze was used primarily on cemetery markers, and no damage functions were available for bronze.

The ambient levels of sulfur dioxide, ozone, and particulate matter in the basin were interpolated from the monitored values recorded on a network of 45 air quality stations in operation between 1978 and 1981 in SCAB. The network encompassed a broad range of pollutant levels and provided reliable information on the pollutant concentrations to which the materials were exposed.

Damage functions are empirically derived mathematical relationships used to estimate the rate at which materials are damaged as a function of pollutant concentrations and other environmental factors. The damage functions were used to estimate the pollution-induced erosion of painted surfaces, corrosion of galvanized fences and other structures, and soiling of painted surfaces. Unfortunately, damage functions are available for a limited number of materials and only those materials for which damage functions are available have been included in the economic estimates provided by this study. Damage estimates were made for painted and galvanized surfaces (which account for about 65 percent of the total exposed materials in the basin). However, for other common materials, such as glass and concrete, no damage functions were available and no estimates were made.

The costs of maintenance were approximated based on cost estimation techniques used by professional construction contractors. The incurred damage

costs are estimated in 1979 dollars and are based on the total square footage of materials exposed in the basin and the frequency of maintenance of these materials.

Major findings of the study include:

1. The materials inventory assembled for the South Coast Air Basin is based on a combination of readily available data, field surveys and telephone surveys. This multipronged approach makes efficient use of resources and permits reliable estimates of materials in place to be assembled. The methodology should be readily transferable to other locations.
2. On the basis of a total area of material exposed, the residential sector dominates the commercial/industrial and public sectors. The notable exceptions are for masonry (brick and stone), concrete, and metals. Approximately seventy-two percent of the total exposed materials is in the residential sector in the basin.
3. Paint, as painted stucco and painted wood, dominates the exposed surface area, accounting for about sixty percent of the total exposed materials. Latex paint is the predominant coating in this category.
4. Damage functions are available for a limited number of materials, and their applicability to environmental conditions in the South Coast Air Basin has not been generally demonstrated. Common materials for which damage functions are not available include glass, brick, concrete and tile. The damage functions for paint selected for this project are based upon results of chamber studies performed at elevated concentrations. While they are useful for estimating the portion of damage due to pollutants, these functions cannot be used reliably to estimate total damage in the real world. The damage function selected for galvanized steel agreed reasonably well with the limited field measurements collected for loss of thickness of zinc on transmission towers.
5. Estimates of the incurred damage costs, based on a maintenance strategy for each material, are presented in Table 2. The estimates have been made based on the survey of materials in place, materials damage functions relating pollutant levels to rate of damage, and the observed pollutant levels and estimated costs of maintenance per square foot of material exposed. These estimated costs include the cost of the increased frequency of painting various building structures and fencing due to pollutant induced damage and the estimated costs for cleaning cemetery markers and statuary; other cleaning and maintenance costs have not been included. Other aspects of economic loss, such as preventative maintenance costs, substitution of more resistant materials, replacement costs, and aesthetic losses are not contained in these estimates. The figures are in 1979 dollars and are estimates for the damage to materials in place in the basin circa 1979. Further, inadequate data exist to quantify the potential errors associated with these estimates, and caution should be applied in using these figures for quantitative purposes.

TABLE 2

ESTIMATES OF INCURRED DAMAGE COSTS BASED ON A MATERIALS MAINTENANCE STRATEGY

Materials	Incurring Pollutant Induced Damage Costs	Type of Impact	Principal Air Pollutants and Other Environmental Factors	Comments
Elastomers	Minimal	Cracking	Ozone, sunlight, physical wear	Protected by addition of antiozonants.
Galvanized structures	\$1.4 million/yr	Corrosion	Sulfur oxides and other acid gasses. Moisture, air, salt particulate matter.	Galvanized fencing is dominated by residential and public sectors, sheet galvanized is used by industry and agriculture.
PAINTS - Erosion				
Latex Paint	\$38.2 million/yr	Surface erosion, discoloration, soiling	Sulfur oxides, hydrogen sulfide. Moisture, sunlight ozone, particulate matter, mechanical erosion, micro-organisms.	Latex & oil paint surface in residential, commercial industrial, and public sectors. Vinyl top coat paint is estimated for commercial-industrial and public use sectors.
Oil Paint	\$2.2 million/yr			
Vinyl Top Coat Paint	\$45,000/yr			
PAINTS - Soiling (Stationary Painted Surfaces)				
Marble cemetery markers and monuments	< \$50,000/yr	Surface erosion soiling, black crust formation	Sulfur oxides and other acid gasses, particulate matter.	Cost of cleaning cemetery markers and incidental monuments.
Outdoor Statuary	\$27,500/yr	Surface erosion soiling, black	Sulfur oxides, other acid gases, particulate matter	Based on estimated number of statues cleaned.
STONE				
Textiles	Minimal	Reduced tensile strength, soiling	Sulfur, nitrogen oxides, particulate matter, moisture washing.	Negligible use of textiles in permanent outdoor exposures, and most textiles use; life limited by non-pollution wear.
Total (Rounded)	\$42 million/yr			Excludes soiling to paint as distinct from erosion.

6. There are approximately eleven million people in the South Coast Air Basin, therefore this total estimated cost is equivalent to about \$4 per person per year. Costs are dominated by the predicted erosion damage to latex paint and/or soiling of surfaces. The lack of preciseness in the damage functions precludes estimates of the variability of the costs.

In summary, the cost estimates presented are subject to wide error bands. Significant classes of materials have not been included in these estimates (such as soiling of windows). Therefore, it is likely that the estimated costs represent a minimum of the increased costs of material damage from pollutants, and that the actual costs may be significantly higher.