Automobile in American Life and Society

The Automobile and the Environment in American History

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Introduction

The impact of the automobile and the auto-centered transport system on the American environment has been enormous. From the manufacturing process to the junkyard, cars—and all motorized vehicles for that matter—consume resources; pollute the air, land, and water; and transform space. The building of automobiles requires gathering vast quantities of metal, glass, plastics, rubber, and other materials, and then assembling thousands of vehicles through human and machine labor. The production process itself consumes enormous amounts of energy, and the factory output produces its own array of pollutants. Once on the road, automobiles are the prime consumers of oil and gas, stimulating increased drilling, transporting, and refining of petroleum products to meet the rising demand. Since the internal combustion engine continues to dominate automobile propulsion, cars dispense vast amounts of pollution in the form of air emissions, noise, used oil, and disposable parts. Derelict or scrapped vehicles pile up once automobiles end their productive lives. Beyond its role as polluter and artifact, the automobile has transformed the city and the countryside as much as or more than any technology designed by humans.

Despite its dramatic impact, the environmental history of the automobile is not easy to depict. Over the years, the car has been viewed as a benefactor as well as an environmental threat, as a boon to individualism, freedom, and liberation, and as the bane of modern society. By the turn of the twentieth century, what had been a technical curiosity, a rich man's plaything, and a noise-belching menace to the nerves of humans and horses alike, began to gain acceptance. Enthusiasts touted the car as a practical,technically reliable means of conveyance that made scores of places more accessible; that was cheaper, easier to maintain, and longer-lived than an urban horse; and that would change the pattern and quality of city transportation for the better. To many people, the speed of the automobile on city streets did not seem any more dangerous than the speed of electric streetcars. Gas fumes seemed no worse than coal smoke from steam engines or manure from horses. Street sweepers praised the automobile for making their job easier: less manure to pick up and cart, fewer stables and manure pits, and not as many animal carcasses to dispose of.

There were, however, early critics of motorized vehicles. Some complained about the "car nuisance," although they may have been referring to little more than reckless driving or the dust kicked up by autos as they rumbled down unpaved roads. Farmers became infuriated with urban car enthusiasts who gave little attention to frightening livestock or disturbing the tranquility of the countryside. Longer-term liabilities often were unforeseen at the time: accidents in excess of those on mass-transit systems; the economic, environmental, and social costs of supporting automobiles and their infrastructure; and ubiquitous smog.

By the time the car became the primary mode of personal transportation in the United States in the 1910s and 1920s, criticism grew harsher and more indicting despite the persistent boosting of its product by the automobile industry. Cars were blamed for most urban problems, including pollution, energy exploitation, congestion, scores of traffic fatalities, suburban sprawl, and the demise of downtowns. One critic referred to the automobile as "the greatest consumer of public and personal space yet created by man." Another suggested that benefits of the automobile are "individualized for those who can afford them" while the costs are "shared by all, regardless of whether or not they can afford them."

The gap between the critics and those who viewed the automobile as the most successful means of personal mobility yet devised created what some have called the "enigma of automobility" or the "automotive paradox." From an environmental perspective, the impact of the automobile is no less complex and, in some cases, no less contradictory.

Environmental Costs of the Automobile Production Process

Mass-produced automobiles like most mass-produced commodities entailed the use of a wide variety and vast quantities of resources, the need for great amounts of human labor and mechanical power, and the generation of copious waste products. Some experts conservatively estimated that by about 1980, two million people were involved in making cars and another three million in producing components, with as many as another twenty million throughout the world depending on motorized vehicles for their livelihood. The business concentration of the automobile industry by the 1920s, especially in the wake of Henry Ford's revolution in mass-production techniques, contributed significantly to the immense scale of production. While there were about 500 small firms in the gasoline-, steam-, and electric-vehicle business in 1910, they produced very few vehicles. The handful of large companies that came to dominate the industry dramatically increased the output. By the 1920s they were producing 98 percent of the world's cars. Between 1920 and 1929 alone, the production of motor vehicles soared from 2.2 million to 5.3 million. In the 1970s, the automobile industry was the world's largest manufacturing concern. Estimates for 1990 suggest that there were 630 million motor vehicles on the road around the world, 460 million of which were private passenger cars. Approximately 40 percent of automobiles globally were in North America.

Historian Mark Foster has estimated that "fully one-third of the total environmental damage caused by automobiles occurred before they were sold and driven." He cited a study that estimated that fabricating one car produced 29 tons of waste and 1,207 million cubic yards of polluted air. Extracting iron ore, bauxite, petroleum, copper, lead, and a variety of other raw materials to process steel, aluminum, plastics, glass, rubber, and other products necessary to construct automobiles consumes limited resources, uses great amounts of energy, and has serious environmental repercussions. In recent years, for example, the automotive industry in several developed countries was a major purchaser of iron and steel (30 percent), lead for batteries (46 percent), aluminum (23 percent), and platinum for exhaust fume control (41 percent). Approximately 75 percent of the cost of the industry's power comes from electricity, but the auto industry also consumes natural gas (15 percent of energy expenditures), and coal and coke (over 8 percent), as well as steam, oil, and propane.

Vehicle assembly plants themselves are major polluters. In the early 1990s, there were 20 engine plants in the United States, more than 40 assembly plants, hundreds of metal stamping facilities, and thousands of suppliers. Automotive plants release sulfuric acid and other smokestack emissions into the air. In addition, the Environmental Protection Agency (EPA) listed car and truck assembly plants among the top ten waste producers in the country. In 1990, the American automotive industry accounted for 1 percent of all hazardous waste or 172 kg per vehicle produced. Paint shops, in particular, utilize large quantities of solvents; in the State of Michigan, these paint-shop solvents account for almost one-fourth of all pollution from volatile organic compounds. The introduction of water-based paints was meant to drastically reduce solvent contamination, but the retrofitting of paint shops is costly, and the large quantities of water used there and elsewhere in the plants do not leave as clean as when they entered. The network of supply industries, building infrastructure, and transportation systems necessary to produce and deliver vehicles to the consumer also must be factored into any discussion of the environmental impact of the automobile.

It is not clear whether the automotive industry pollutes or has polluted disproportionately to other forms of manufacturing in the United States. And in recent years, automobile manufacturers like other industries have been held accountable for some pollution standards or have attempted to improve some conditions voluntarily. That aside, the scale of the operations are such that one cannot dismiss the role of production in the total picture of the impact of the automobile on the environment.

Energy Use and the Internal Combustion Engine

The first gasoline-fueled, four-stroke cycle engine was built in Germany in 1876. In 1886, Carl Benz began the first commercial production of motor vehicles with internal combustion engines. By the 1890s, motor cars reached their modern stage of development. In fact, the models of that decade were so successful that there has been no fundamental change in the principles of the ordinary automobile engine since that time.

It took several more years for the internal combustion engine to sweep the American market, however. General conditions, such as the expansiveness of the nation, the lack of decent roads, and the relatively well-developed urban transit system, worked against adoption of any and all motor vehicles for a time. Mass production of gasoline-powered cars, however, brought to the market a vehicle that was modestly priced, easy to maintain, relatively fast and powerful, able to travel long distances, and fueled by a cheap, abundant, widely-available source of energy.

Before the era of the Model T, gasoline-fueled vehicles had stiff competition from steam-driven and electric cars. In fact, of the 4,200 cars built in the United States in 1900, only one-fourth employed internal combustion engines. And of the approximately 8,000 automobiles on the road, most were steam-driven. Steam had been used as early as 1769 to power a road vehicle. French Army engineer Nicholas Joseph Cugnot designed a three-wheel truck for hauling artillery. Experimentation with steam-powered vehicles began in the United States in the 1780s primarily in the Northeast. Into the nineteenth century, however, steam-engine technology tended to focus on locomotives rather than cars.

Particularly noteworthy in the United States were steam cars produced by twins Francis E. and Freeland O. Stanley, who had been school teachers in Maine. For several years, the “Stanley Steamer” was the fastest vehicle on the road. In 1906, the Stanley Rocket set five world speed records in Daytona Beach, Florida, hitting over 127 miles per hour. By the 1910s, however, the Stanleys were producing only 600 to 700 vehicles per year. Despite the simplicity of their engines, fast acceleration, low pollution, economy, and great power, the early steamers started up slowly and ran noisily, had unreliable controls and problems with freezing, and required extensive engineering knowledge to operate. Although many of the steamer’s weaknesses were overcome, they suffered from little infusion of capital into their production, some untimely accidents, and vigorous competition from the mass-produced gas-powered cars that had overtaken the market by the 1910s.

The electric car, utilizing rechargeable batteries, was another promising alternative to the gas-powered vehicle. In 1900, more than one-quarter of the almost 4,200 American automobiles produced were electric. However, twenty years later the commercial viability of the electrics had ended. As with the steamers, electric cars had some decided advantages over the motorcar: ease of operation, no emissions of foul odors and gases, and a quiet ride. Yet as a road vehicle, electric cars had a major problem: limited range. At the turn of the twentieth century, they could only go twenty miles before requiring a recharge. Furthermore, storage-battery life was limited and the batteries themselves were bulky. Even the celebrated Thomas Edison could not produce a viable battery in time to compete with gasoline-powered cars. As one writer noted: “Like many products before and after, the electric car was a technological success that found no more than a miniscule market; it was a spectacular flop.”

With greater availability of gasoline and oil lubricants after the gigantic Spindletop oil strike in southeast Texas in 1901, and favorable publicity from automobile race results, the gasoline-powered car claimed performance superiority over its competitors. In 1900, Ransom E. Olds switched from producing steam-driven cars to producing gasoline-fueled vehicles, and in 1903, Henry Ford founded a motorcar company specializing in automobiles with internal combustion engines. When Henry Ford put his mass-produced Model T on the market in 1908, the car ceased to be a toy for the rich and firmly entrenched the internal-combustion vehicle as the standard.

Demand for gasoline was the major impetus to the growth of the petroleum industry in the twentieth century. Gasoline consumption soared from less than three billion gallons in 1919 to approximately fifteen billion in 1929, 46.5 billion in 1955, and more than 135 billion in 2002. By 1973 transportation was responsible for more than half of all consumption of petroleum in the United States; by 1990 almost 64 percent. Since 1975, the United States has consumed more oil for transportation than it produced. Today, automobiles alone are responsible for almost 90 percent of the energy consumed for travel in the U.S.

Over the years, changes in the design, size, weight, and power of automobiles all contributed to greater gasoline use. The addition of amenities such as air conditioning, power steering, power brakes, automatic windows, and automatic transmissions reduced fuel economy. Quality of gasoline—not simply quantity—was crucial to automobile performance. The discovery and commercialization of tetraethyl lead as an antiknock agent was a major breakthrough. Criticized for blaming poor performance on the fuel rather than on engine design, Charles F. Kettering and Thomas H. Midgley were soon praised throughout the automobile industry for perfecting the

additive in 1922. In 1926 an octane scale for gasoline was introduced by the Ethyl Corporation (a joint venture between Jersey Standard and General Motors). With higher octane antiknock fuels, higher compression engines could be produced. The economic benefit of such a venture for both the automotive industry and the petroleum industry overshadowed questions of safety in the production of tetraethyl lead and questions of health through the use of leaded gasoline in general.

Since petroleum products were so essential to the proliferation and use of the automobile, the environmental implications of drilling for, transporting, and refining oil assume an important role in the relationship of the automobile to the environment. The euphoria over striking oil was not matched with foresight and restraint in producing and marketing it. Abundance of “black gold” appeared to be a permanent blessing for the United States, and in the early years particularly, waste and overproduction was due to several factors: poor drilling and storing techniques, natural disasters, the competitive market, simple disregard, and greed. Many of the problems oilmen encountered in fields across the continent were first experienced in Pennsylvania in the late nineteenth century before the surge to refine oil for fuel in the West and Southwest.

The patterns of waste and the disregard for conservation measures at Oil Creek and elsewhere in Pennsylvania were remarkably similar at Spindletop despite years of experience in drilling for oil. Great fires periodically spread across the fields, with one fire burning 62 derricks and sending flames 1,000 feet into the air. The general squandering of oil was legendary. In 1902, the *Oil Investors' Journal*estimated that 10 million barrels of oil at Spindletop had been wasted since the initial strike. To impress investors, oil promoters often opened the wells, sending gushers of 125 feet into the air.

The basic urge to get rich quick, however, usually meant depleting supplies as quickly as possible, despite warnings from geologists about the dangers of extracting too much, too quickly or wasting substantial amounts along the way. Through the “Rule of Capture,” which dominated the production of oil until the 1930s, those who owned the surface property over a common oil pool could keep all the oil and gas that they took from wells, regardless of the possible drainage from adjoining property. In most respects, the problem of waste at the wellhead was viewed as an economic problem. Conservation practices, when implemented, ultimately produced oil in a more rational fashion by protecting prices and limiting wild fluctuations in supply. These practices, however, were usually limited to large companies—not wildcatters—that controlled major sources of supply and benefited from industrial stability.

Beyond overproduction and squandering of oil, drilling and refining polluted the land, air, and water where oil was taken from the ground and where it was processed for marketing. Localized pollution in areas such as Beaumont-Port Arthur, Texas, was serious but rarely attracted attention from oil companies or state government before World War I. Drain-offs of crude soaked the ground in the fields immediately around the wells. Rapid pumping of oil led to the introduction of salt water into the underground pools as well as into local water supplies. Among the wells, the pumping stations, and the tankers, spillage was frequent. When strikes occurred it was common for thick, yellow fog laden with sulfur to engulf houses and other structures in the area. In addition, early refineries were built with little regard for environmental concerns: unrecovered petroleum was simply discarded in the most convenient location; open (sulfurous) flames from burning crude were noticeable everywhere. Floods along the coast washed oil into the rivers, streams, lakes, and the Gulf of Mexico.

In the early twentieth century, oil conservation laws in some states tried to cope with the most egregious practices in the oil industry, concentrating on casing requirements and the plugging of wells. With the major discoveries in the Southwest and the rise in demand for gasoline, legislation shifted to production controls. State and federal authorities, although concerned with potential oil depletion, gave scant attention to oil-field waste, and other forms of pollution and self-regulation of environmental problems within the industry was a very low priority. In Congress, efforts to pass legislation to control oil-related pollution issues met with stiff resistance from oil-producing states. Secretary of Commerce Herbert Hoover in the Coolidge administration proposed curbing oil discharges from shore plants as well as from ships, which resulted in the Oil Pollution Act of 1924. The law was a weaker version of Hoover ’s proposal, however, offering inadequate enforcement provisions and dealing only with dumping fuel at sea by oil-burning vessels.

Only after World War II, with a system of production controls in place, did attention turn to preventing oil field pollution. Population growth, urbanization, and industrialization in the oil-producing states in particular influenced this effort. Most important, the increased demand for water by cities, farms, and industry encouraged the passage of laws to prevent the contamination of fresh water supplies. In the late 1940s, several states adopted more sophisticated petroleum conservation laws to protect groundwater and to reduce external damage caused by oil-field discharges. Much more limited success was achieved in controlling petroleum-related pollution in the Gulf Coast refining region. Hydrocarbons and other chemical pollutants blanketed the skies over Beaumont-Port Arthur and along the Houston Ship Channel. Water pollution in estuaries, tidelands, and especially in the Ship Channel added to the environmental deterioration.

The oil industry preferred to deal with pollution questions internally. However, those most directly affected by the contamination did speak out. In the early 1950s, the actions of a citizen’s group from the area near the Houston Ship Channel led to the establishment of a water and air pollution control section in the Harris County Health Department. Additional successes were thwarted by the state court, which handed down several decisions making it more difficult to prosecute companies responsible for the pollution. In the 1960s, the argument that further pollution threatened economic growth was persuasive. Charges by federal investigators that the Houston Ship Channel had the worst water pollution problem in the state, among other things, encouraged the Texas legislature to pass a clean air act in 1965 and a water quality act in 1967. Enforcement proved minimal, however.

World attention turned to the problem of oil pollution in March 1967, when the supertanker *Torrey Canyon* ran aground off the coast of England, spilling most of its 120,000 tons of crude into the sea. In May, President Lyndon Johnson initiated a study of oil pollution problems, but no major change came in federal offshore policy in the United States. On January 28, 1969, however, Union Oil's Well A-21 blew off the California coast at Santa Barbara. The hole was capped quickly, but thousands of gallons of oil escaped from a fissure in the ocean floor. By February 1, the pollution extended along five miles of beach, and the leak ultimately released 235,000 gallons of crude with a slick of 800 miles. Throughout February and into March, the crisis continued with no immediate end to the pollution of the beaches. Efforts to use chemical dispersants on the oil were started and stopped several times. Union Oil attempted other methods but to no avail.

Washington and Sacramento responded with investigations and studies. The investigatory process offered little immediate relief to Santa Barbara, however. Lawsuits against Union Oil from commercial fishermen and owners of beachfront property soon followed, as well as state lawsuits against the federal government. Citizen groups, especially GOO-Get Oil Out, protested against the remaining oil operations. Efforts to permit Union Oil to resume offshore production simply led to renewed blowouts and leaks. By March 6, the oil was washing up on San Diego beaches, and it was not until the end of the month that the worst leaks were plugged.

The Santa Barbara oil spill brought into question the rush to exploit offshore oil, corporate responsibility for environmental disasters, and the need for environmental protection. At the time of the spill, 925 wells had been constructed along the coastal tidelands from Santa Barbara to Los Angeles. Beyond a state-imposed three-mile coastal limit barring drilling, the federal government controlled the leases, granting its first one in 1963. Fearing that poorly regulated wells in the "federal zone" could pollute the state's beaches, California demanded jurisdiction beyond the three-mile limit, but the request was denied. Industrial concern over oil leaks was negligible before the Santa Barbara incident.

The aftermath of the Santa Barbara crisis was significant. Union Oil assumed liability for the blowout, but the financial settlements were well below the total damage costs. Congress tightened regulations on leases and made offshore operators liable for cleaning spills. Luckily, the worst fears about the damage to the California coast were not realized. While more than 3,500 birds died, damage to wildlife and the beaches was not permanent. But the spill was a dramatic event that helped stimulate the growth of the modern environmental movement, and moved the federal government toward the passage of the omnibus environmental law, the National Environmental Policy Act (NEPA), in 1969.

Despite the Santa Barbara spill, the search for new sources of petroleum inevitably led to increased interest in offshore wells. Ocean drilling and greater tanker traffic guaranteed more blowouts and spills. In February 1970, the *New York Times* reported three Exxon oil spills in one month: 15,000 gallons off the coast of Florida, 3 million gallons in Nova Scotia Bay, and 50,000 gallons a day for several weeks in the Gulf of Mexico. During 1975 alone, there were 12,000 reported spills resulting in 21 million gallons of oil dumped into U.S. waters.

In 1977, the Coast Guard initiated more stringent regulations for tankers, but illegal flushing continued. An exploratory well some fifty-seven miles off the Yucatan Peninsula experienced a massive blowout on June 3, 1979—the same year the *Amoco Cadiz* tanker spilled 200,000 tons of oil off the coast of Brittany, France. While the Ixtoc well in the Bay of Campeche was a Pemex venture, it threatened the Texas coast as much as the Mexican coast. The explosion and fire destroyed the rig and created a slick sixty to seventy miles long. The ultimate discharge not only exceeded the Santa Barbara spill but also exceeded the 1977 Ekofisk blowout in the Norwegian North Sea—the largest on record at the time. The new spills reignited the controversy over oil exploration along the continental shelf. In the wake of the energy crisis in the 1970s, the Nixon administration and its successors had continued to authorize leasing of federally controlled sites through the Department of the Interior. Coastal states, especially California, were concerned about leaving the fate of their coastlines to the Interior Department and the oil companies. Even after the passage of NEPA, many environmentalists were concerned that regulation was more ceremonial than substantive.

The major battle over oil production during the 1970s, however, was fought not over water, but land: the Alaska pipeline. Oil exploration was on the rise in the late 1960s after the world oil glut receded. After an unsuccessful attempt near the Sagvanirktok River, Atlantic Richfield (ARCO) struck a massive field (estimated at 4.8 billion barrels) at Prudhoe Bay in 1968. Soon there was growing support for the construction of a pipeline to run 800 miles from Prudhoe Bay south to the Port of Valdez. Environmentalists fought against the pipeline, fearing that it would destroy precious wilderness areas. The 1973 oil embargo undermined their case, and, in that year, Congress passed the Trans-Alaska Pipeline Authorization Act. Thousands of people poured into Alaska seeking jobs with the Alyeska Pipeline Service Company. The first oil began to flow three years later.

In 1989, the collision of the *Exxon-Valdez* oil tanker with a reef in Prince William Sound became the most famous—and infamous—discharge of oil since the Santa Barbara spill and part of the continuing debate over the pipeline and other efforts at exploiting Alaskan oil. The tanker burst open and discharged thousands of gallons of crude into the unspoiled waters off the coast of Alaska. Unfortunately, the *Exxon* Valdez accident would not be the last. At the time of the trial of the *Exxon Valdez's* captain, Greenpeace published an advertisement with a broad critical indictment: "It wasn't his driving that caused the Alaska oil spill. It was yours."

Auto Emissions and Air Pollution

The Santa Barbara oil spill was a dramatic reminder of the risks inherent in the search for energy resources. Emissions from the internal combustion engine, however, have proved to be the most significant environmental consequence of oil production. Street cleaners who sang the praises of the motor car for delivering them from tons of horse manure could not appreciate that the environmental panacea of one generation proved to be the bane of another. The technical limits of the internal combustion engine and the scale of automobile use produced devastating forms of pollution.

Some pollution crises in the postwar years were harbingers of things to come. In 1948, a temperature inversion kept a dense smoke cloud of sulfur dioxide and particulate matter close to the ground for six days in the steel mill town of Donora, Pennsylvania. On the fifth day, October 30, seventeen people died, followed by two more deaths twenty-four hours later. Almost 43 percent of the townspeople became ill, with more than 10 percent (1,440) "severely affected." The tragedy at Donora made postwar Americans aware of the health hazards of air pollution. Those dangers were reconfirmed by the "killer smog" that hit London in 1952 (4,000 deaths) and the serious smog attack in New York City in 1953 (200 deaths). Congress enacted the National Air Pollution Control Act in 1955 to generate research on air pollution, but how automobile emissions fit into the story took several years to evaluate and even longer to address.

A relatively new source of air contamination, automobile emissions posed different problems than manufacturing discharges such as coal smoke. Before the Industrial Revolution, levels of toxic chemicals in the air were relatively low, but increased fossil-fuel production and use dramatically decreased air quality. The addition of many thousands of cars on the road in the years after World War II intensified the spread of air pollution, added more and newer sources of pollutants, and most immediately threatened many major cities.

In the 1940s, citizens of the car-dominated Los Angeles basin complained about a white or sometimes yellow-brown haze that made their eyes tear. They referred to this irritation as "smog." The word was taken from a combination of "smoke" and "fog," a term purportedly coined in 1905 by Dr. H.A. Des Voeux of London ’s Coal Smoke Abatement Society. The more recent version of smog, primarily from automobile emissions, is composed of a complex of carbon monoxide, hydrocarbons, sulfur oxides, nitrogen oxides, waste heat, and aerosols (liquid droplets, solid particles, and other various mixtures of liquids and solids suspended in air). Tropospheric ozone, located a few feet above ground, is another significant component of smog. In the late 1980s, at least 60 million people in North America regularly breathed air that failed to achieve federal air quality standards established ten years earlier; during the summer heat wave in 1988, the number rose to 120 million. Ozone is clearly one of the worst offenders, especially in cities such as Houston, Los Angeles, Baltimore, New York, Philadelphia, Washington, D.C., and Toronto.

Individually or together, the various components pose a health hazard to humans. Auto emissions can cause headaches, contribute to lung cancer, emphysema, and various other respiratory and cardiovascular problems, and have been linked to low birth weight in infants. They also modify weather conditions, damage vegetation, and eat away at rubber, textiles, dyes, and other materials.

The use of tetraethyl lead as a gasoline additive in 1923 introduced yet another toxic substance to automobile emissions that threatened human health. Concerns among public health officials about the poisonous nature of the substance did not deter General Motors and others from promoting leaded gasoline. As environmental historian Ted Steinberg noted, “With the burning of huge quantities of gasoline (especially in the three decades after 1950), lead was deposited on the soil and, unknowingly, tracked into houses across the nation. Infants crawling on the floor then picked it up on their fingers and ingested it, interfering with the development of their nervous systems and contributing to hyperactivity and hearing loss, among other effects, although it would be decades . . . before the full scope of the problem became evident.” Unfortunately, lead does not break down once released into the air, and between the 1920s and 1986—when it finally was being phased out as a gasoline additive—seven million tons of lead was spewed out by cars across the country.

While air pollution from cars was a growing problem throughout the immediate postwar period, it was not an issue among automobile manufacturers, oil companies, or the public. Los Angeles, the "smog capital of America," was probably the first city to raise major public concern over auto emissions, and became the living laboratory for studying the causes and effects of massive doses of smog. The State of California also was the first state to establish new-car emission standards.

As early as 1959, eye irritation was reported in Los Angeles County on 187 days; in 1962, 212 days. A typical car produced in 1963 (without pollution control devices) discharged 520 pounds of hydrocarbons, 1,700 pounds of carbon monoxide, and 90 pounds of nitrogen oxide for every 10,000 miles traveled. In 1966, 86 million of approximately 146 million tons of pollutants discharged into the air in the United States was attributable to motor vehicle traffic.

Beginning in 1947 Los Angeles had reduced sulfur dioxide emissions by banning the use of coal and fuel oils for industrial purposes, but the smog problem continued to increase. In the 1950s suspicions were being raised about the contribution of motor vehicles to the air pollution problem of the area. Dr. A.J. Haagen-Smit and other scientists conducting pioneering chemistry research at the California Institute of Technology discovered that nitrogen oxides and hydrocarbons exposed to sunlight produced secondary pollutants (photochemical smog or PCS) that caused eye and throat irritations and reduced visibility in the Los Angeles area. Further studies indicated that the complex and various pollutants existing in automobile emissions came from four sources: engine exhaust, crankcase blowby (through the engine ventilation system), the carburetor, and the fuel tank. These investigations were central to the development of various emissions-control technologies.

Multiplied by thousands of cars, the smog problem in Los Angeles was critical. California became the logical testing ground for several emissions-control devices and some pioneering legislation. Initially, neither the automobile industry nor the petroleum industry was a willing participant in addressing the problem. For its part, the auto industry was not interested in committing time or money to redesigning its cars, and only reluctantly and largely because of new legislation was forced to retrofit cars with emission-control devices. (Interestingly, little serious consideration was given to encouraging or requiring motorists to alter their driving habits.)

As early as 1953, Los Angeles County Supervisor Kenneth Hahn inquired of Detroit automobile makers as to whether research was being conducted to eliminate emissions. The response was vague. With the threat of mandatory federal regulations, the auto industry began to install crankcase blowby devices (which returned unburned gases to the combustion chambers) on their cars. This was a significant advance because crankcase blowby produced 25 percent of the engine's hydrocarbon emissions. This equipment became mandatory on all cars sold in California beginning with the 1963 models.

This was only a start, since no effort was made to control exhaust emissions that were responsible for 55 percent of the hydrocarbons, most of the waste heat, and all of the carbon monoxide, nitrogen oxides, and lead emissions. Once again the industry balked, but in 1966 California required exhaust-control devices on all new cars. However, the 12 percent drop in hydrocarbon emissions and reduction in carbon monoxide experienced in Los Angeles between 1965 and 1968 was accompanied by a 28 percent rise in nitrogen oxides. By 1968, nitrogen dioxide, which is highly poisonous, exceeded the "adverse" level on 132 days. The serious increases in nitrogen oxides were due to the inability of available antiemissions technology to act on them, as well as to the increase in automobiles and rising gasoline consumption. A new technical fix was sought from the automobile industry and, in response, catalytic exhaust devices were developed to convert nitrogen oxides into harmless by-products. Catalytic converters were required on all 1975 cars sold in California. Leaded gasoline, however, played havoc with the catalysts. One solution was to use lead-free or unleaded gasoline. (Another was the unauthorized removal of the devices by motorists.) While non-leaded gas became available, the complete phase-out of leaded gasoline, as stated earlier, did not commence until 1986.

Outside of California, the states moved slowly to combat automobile emissions. By 1966, motor vehicles contributed more than 60 percent of the pollutants in the atmosphere throughout the nation. Temperature inversions in at least 27 states and the District of Columbia produced serious smog problems. The more widespread use of trucks and airplanes exacerbated the nation's air pollution problems.

It became apparent during the 1960s that smog was not a local problem, but a national one requiring the attention of the federal government. While California still led the way in emissions-control legislation, federal laws moved toward recognition of the problem. The 1963 Clean Air Act for the first time gave the federal government limited enforcement power over interstate pollution. The Motor Vehicle Air Pollution Act of 1965 produced national standards comparable to California law for the 1968 model year. Also in 1967, the Air Quality Act was the first piece of federal legislation designed to control lead emissions. Federal funds became available to defray part of the cost of inspection programs. Hydrocarbon emissions came under federal jurisdiction in 1968.

The meteoric rise in environmental concern, the dissatisfaction with existing federal laws, and the lackluster accomplishments of the states provided the momentum for the 1970 Clean Air Amendments. Dealing with both auto emissions and stationary sources of pollution, the new legislation was the most stringent air pollution law ever passed in the United States. An amendment to the 1970 Clean Air Act called for further reductions in emissions and authorized the Environmental Protection Agency (EPA) to set emissions standards for new automobiles and other motor vehicles concerning pollutants that would adversely affect human health.

Intentions, however, were not always equal to actions. Implementation of the Clean Air Amendments was made difficult by a reluctant automobile industry and the energy crisis of the early 1970s. The 1970 act gave the auto industry a temporary way out of meeting the tougher standards. Under the provisions of the act, the EPA administrator could grant a one-year delay if the companies made "good faith" efforts to meet the new standards. Some critics questioned whether the manufacturers had, in fact, made such a gesture, since they relied on the research and development work of independent companies for emissions-control technology rather than utilizing their own resources.

EPA Administrator William Ruckelshaus denied the delay on the grounds that the companies were capable of meeting the 1975 deadline. Four auto companies then sued the EPA for refusing to extend the deadline, and, in 1973, the Court of Appeals ruled in favor of the plaintiffs. The onset of the energy crisis prompted Congress to extend the deadline further, and apprehension about the safety of the catalytic converters again pushed back the deadline. In 1977, a three-year suspension was granted.

While emissions standards attempted to address one environmental problem associated with motor vehicles, it actually helped produce another. During the period frpm 1968 to 1974, with the primary emphasis of regulation on emissions control, fuel economy of motor vehicles suffered, thus increasing demand for gasoline. One way of enhancing fuel economy was reducing the weight of vehicles, and data for 1977-1980 indicates that fuel economy improved almost in direct proportion to reduced vehicle weight. (Of course, concerns about the safety of vehicles arose as some cars on the road became lighter, while older models retained their bulk.) The introduction of the oxidation catalytic converter in 1975 also helped to improve fuel economy as well as reduce emissions. Electronic engine control later added another layer of technology.

The energy crisis of the 1970s produced a mixed record with respect to auto emissions. The American automobile industry, especially Chrysler, was woefully unprepared to meet the challenge of fuel economy demanded by the rise in gasoline prices. Americans turned to small Japanese and European cars, while Detroit plunged into a deep depression. Alternatives to the internal combustion engine were not quick in developing either. One exception was the greater availability of the more economical and less-polluting diesel engine. Faced with the crisis in the automobile industry, the federal government sought to ease air pollution and safety standards. In this way, the energy crisis blunted enthusiasm for more stringent air pollution laws. However, the mandated 55-mile-an-hour national speed limit and the decline in gasoline usage (by more than 5 percent) contributed to some reductions in air pollution.

Despite the mixed signals about the chance for cleaner air—more regulation, more technology, but also more vehicles and more gasoline usage—progress was made in reducing some forms of air pollution by the late 1980s. Carbon monoxide, hydrocarbon, and nitrogen oxide emissions began to decline. Lead usage in gasoline dropped by 99 percent between 1975 and 1988. Yet 44 urban areas failed to meet ambient air standards for carbon monoxide, and 101 urban areas failed to meet air standards for the serious problem of ozone.

The Clean Air Amendments of 1990—debated vigorously in Congress especially by those who feared a watering down of standards and others who did not want more teeth in the older law—substantially revised the 1970 and 1977 acts. Two of the eleven titles focused particularly on transportation. They involved a new plan to classify cities according to the severity of their emission problems and their degree of attainment of earlier goals, with different levels of action required for each category. The categories were: marginal, moderate, serious, severe, and extreme. For example, “marginal areas” for ozone had to complete an emissions inventory and reduce volatile organic compounds emissions (reductions from other federal programs could be credited toward those reductions). Urban communities classified as “nonattaiment areas” were required to take more substantial actions.

The new law also set more stringent emissions standards for automobiles and some trucks for model years 1996 to 2003. Efforts to tighten exhaust standards essentially ratified innovations underway in California (referred to as a Phase I strategy) and being enacted by other states. The automobile industry, for its part, was already making good progress toward the California standards. However, the administration of George H.W. Bush strongly opposed more stringent exhaust standards like those to be implemented in California (Phase II) in 1996. Instead, it promoted a “clean fuels” and a “clean car” alternative, which mandated the use of new fuels (reformulated gasoline, methanol, ethanol, and natural gas) and the introduction of cleaner cars in cities with the worst ozone problems. Predictably, the oil and automotive industries strongly opposed the “clean fuels” and “clean car” strategies, but they accepted a diluted version rather than be forced to accept something similar to California ’s Phase II exhaust standards.

Despite the lukewarm provisions for cleaner cars, the new policy helped to stimulate interest in alternatives to the standard internal combustion engine. Some movement in this direction had occurred during the energy crisis and earlier with the rotary engine and other technologies. Also, under certain conditions some electric-powered vehicles were in use, especially in urban settings. Cars equipped with electric batteries or hydrogen fuel cells (zero emission vehicles or ZEVs) and even hybrid systems (sporting a combination of electric and gasoline power) were back on the drawing board and some even entered the market. For example, Amory and Hunter Lovins of the Rocky Mountain Institute promoted the development of a “Hypercar,” an aerodynamically designed vehicle powered by a

small electric-generating engine utilizing gasoline, liquid gas, or hydrogen cell. The Lovinses also have promoted various forms of a hydrogen-powered vehicle.

Legislation and technical fixes were a start in the battle for clean air, but no magic solutions were achieved overnight. The automobile and oil industries continued to resist tougher standards. The public paid homage to clean air but resented carrying the burden of responsibility through higher costs and reduced automobile performance. Cities groped with ways to keep air quality from diminishing further. But as long as Americans cherished the automobile, emissions problems would remain. The intimacy between the individual and an energy source was nowhere more apparent than in the relationship between Americans and their cars.

Small, imported cars made in-roads into the American market beginning in 1957, while American automobile manufacturers concentrated on bigger vehicles with larger engines. The Big Three—GM, Ford, and Chrysler—were not convinced that a large enough market existed for small cars. As long as gasoline was abundant and cheap, they would produce more powerful automobiles. High-compression engines offered greater horsepower and quicker acceleration for highway travel. Automatic transmissions—an option on 91 percent of the cars sold by 1970—made driving easier. These were luxuries of a high-octane age, luxuries to which the Big Three committed their futures. The side effects of more cars, bigger engines, and automatic transmissions, however, were loss of fuel economy and increased air pollution.

Noise, Visual Pollution, and Derelict Cars

While air pollution is the best known and most-discussed environmental impact of operating automobiles, it is not the only one. Traffic noise, while in no manner on a par with air pollution as an environmental hazard, is nonetheless significant. As in other cases, automobiles did not invent noise or noise pollution. Especially in and around cities, throngs of people, factory machinery, steam whistles, the clop-clopping of horse hooves, screeching brakes and grinding gears from streetcars, and clanging bells all contributed to urban din. Indeed, the eventual use of rubber tires on motor vehicles was regarded as a godsend to inner-city traffic. Nonetheless, the volume of motorized vehicles crammed into cities added a new dimension to the noise problem. “While the sources of annoying sounds in a city are plentiful,” one observer noted, “few have been extending their influence as rapidly and relentlessly as the noise of motor vehicles.” While cars are most plentiful, trucks, buses, and motorcycles are guilty of greater sound levels per vehicle. And while traffic noise seldom reaches levels that may produce permanent damage to human health, it can increase stress and contribute to hearing loss, and is at least an irritant and nuisance—and sometimes more.

Cars also contribute indirectly to visual pollution or visual intrusion. The whole automobile infrastructure (discussed more fully below)—paved over landscapes for roads, highways, and parking lots; high-rising cement interchanges; service stations, auto dealerships, and garages; fast food restaurants; strip shopping centers; car washes; and automobile-level billboards, signs, and other forms of advertisements—assault the aesthetic sensibilities of many people.

Possibly the most dramatic form of visual pollution in the automobile age is the derelict car along the side of the road. New York City alone had to contend with 57,000 abandoned automobiles in one year (1969). And scrapped tires create their own land-pollution problem. Before, during, and soon after World War II, rubber from old tires could be reused to make new ones. In the 1960s, however, recycled rubber was in much less demand because of the surplus of synthetic rubber and changes in tire manufacturing, such as the production of steel belted radials. In 1996 there was a national stockpile of about 700 to 800 million scrap tires. Too many tires were left along roadsides or dumped anywhere, creating not only eyesores but good breeding ground for mosquitoes. Fires in tire dumps produced billowing smoke and mounds of toxic sludge. While making tire-derived fuel or producing ground rubber for a variety of uses has been carried out for some time, it is susceptible to market changes.

Other parts of derelict vehicles also cause disposal problems. Probably the most notorious are batteries. In 1986 alone approximately 941,000 tons of lead were used to produce batteries, of which 78 percent was discarded. Other heavy metals, such as cadmium and mercury, are used in great quantities in making batteries and also find their way into the waste stream even after new laws were passed restricting battery disposal practices. Automobiles also generate waste products in the form of plastics, glass, antifreeze, motor oil, transmission and brake fluid, etc.

The good news is that approximately 65 percent of the weight of the average car is composed of steel and iron, metals that are valuable to the steel industry. There are 12,000 auto dismantlers in North America and scores of ferrous scrap dealers. In 2000, more than 14 million tons of steel was recycled from cars, with a recycling rate for automobiles exceeding 95 percent. But despite this recycling effort, automobiles continue to pose an environmental challenge in the United States in any number of ways.

The Automobile’s Imprint on the Landscape

There is little doubt that the widespread use of the automobile, especially after 1920, changed the rural and urban landscapes in America. It is overly simplistic to assume, however, that the automobile was the single driving force in the transformation of the countryside or the modernization of cities. In some ways automobile transport was a crucial agent for change, but in other cases it merely accelerated ongoing changes.

In several respects, the automobile made its impact felt first in rural areas where cars were used for touring and recreation on the weekends as opposed to replacing existing transit that brought people to and from work in urban areas. Some of the earliest paved roads were landscaped parkways along scenic routes. Of course, rural people were not always very pleased when urban drivers rutted unpaved roads, kicked up dust, and generally frightened or even injured livestock. Yet, cars potentially could help confront rural problems—isolation, the high cost of transporting farm products, and the labor of farm work. Although farmers may have resisted the automobile at first, by the 1920s per capita automobile ownership favored the rural family. Adoption was uneven in rural areas, however, depending on income, availability of cars, the continuing reliance on horses, and other factors. Automobile manufacturers did not lose sight of this market and courted potential customers with advertisements touting that cars were “Built for Country Roads” or promoting vehicles that would lead to “The Passing of the Horse.”

Highway construction, also irregular in rural America, nonetheless influenced rural settlement patterns. Already in the post-World War I era, one might find fringe areas on the outskirts of cities that were neither rural nor urban. Settlements along the roads might be populated with farmers, people who lived in the country but worked in the city, and service areas with a variety of roadside business catering to automobile traffic.

An array of businesses trying to catch the attention of motorists began to spring up. Crudely built shacks beckoning tourists to spend the night made way for reasonably priced tourist courts, and ultimately the ubiquitous “motel” (a term likely coined in the mid-twenties as a play on the word “hotel”). Subsequent uniformity of style and service of motels—like in the case of Holiday Inns or Howard Johnsons—provided motorists with a clear expectation of what to expect if they stopped there, and how much they were likely to pay. Florida was an early leader in building accommodations for tourists with 178 tourist courts and camps operating by the mid-1920s. Complementing the tourist court was the roadside restaurant or eating establishment. Long before the chain restaurants like McDonald’s or Denny’s there were hundreds of “mom and pop” eateries serving anything from quick meals to full-course dinners.

Most important of all were filling stations for refueling, and ultimately garages and service stations to aid the traveler suffering an untimely breakdown. In the early days of the automobile—before pumping devices were invented—travel required careful planning. Gasoline had to be obtained at “bulk depots.” These were located outside of the cities and the fuel was provided in cans or other containers. (Later gasoline for sale to motorists was transported in horsedrawn tank trucks by wholesalers to commercial customers in towns.) Sometimes the distances between the depots were too great for some motorcars, and a long walk or the help of a tow was necessary from a friendly soul with a horse. In 1905 the Automobile Gasoline Company in St. Louis employed a gravity-fed tank for fueling cars and opened the first “gas station.”

As automobile sales increased, the demand for fuel led to a more systematic way of delivery, and in 1914 Standard Oil of California opened a chain of 34 standardized stations along the West Coast. Soon gasoline pumps were being installed not only at the new service stations, but in front of hardware stores, feed companies, livery stables, and a variety of other retailers. Curbside pumping, although common in cities, was less common in the countryside, where filling stations developed. Like early tourist camps, the first service stations could be converted barns, stables, or warehouses—a far cry from the multi-purpose facilities of today. Ultimately they came in a variety of designs—from the mundane to the ultramodern—literally creating an automobile-oriented landscape quite unique from what had come before. Outdoor advertising, especially the billboard, followed the roads into the countryside and hawked all manner of products and services, including the new roadside businesses themselves. As one architectural historian noted: “Speed blurs details, signs have to be big and bright.” Automobile commercialism, not aesthetics or tastefulness, was the prime characteristic of the new advertising form. In the early 1930s, a survey was conducted along 47 miles of highway between Newark and Trenton, New Jersey. That stretch of highway included 300 gas stations, 472 billboards, and an additional 440 commercial uses. As much as creating changes in the rural landscape, the new roadside businesses had a major commercial impact beyond what anyone could have imagined.

Modern American cities also bear the imprint of automobiles and other motorized vehicles. In some cases, more than fifty percent of the ground area in the central business district of a city by the early 1960s was devoted to streets and parking spaces. While other forms of transportation before the automobile sometimes required even more street space, recent street and parking data often do not include the space necessary for businesses or services devoted in whole or in part to the automobile, such as gas and service stations, automobile dealerships, and automotive supply stores.

The “rise of the automobile city” or the retrofitting of cities to accommodate motorized vehicles must be understood within a rather broad historical context to be truly meaningful. As one social scientist has pointed out, “The majority of cities and towns have had the bulk of their urban fabric determined over many generations.” There has been congestion in central cities due to pedestrians, horses, carriages, bicycles, and streetcars. Saying this does not dismiss the quite unique and profound physical impact of the automobile. It only reconfirms that it is not the only technology that has helped to make or remake cities. Yet, since World War II in particular, it is difficult to visualize cities, their suburbs, and the urban hinterland in the United States devoid of the car.

When we think about busy city life in the twentieth century, we inevitably think about traffic and congestion. While automobiles did not invent traffic snarls, they did create new problems in cities, especially with the glut of mass-produced automobiles. Cars and trucks occupy greater street area per capita than mass transit. The large numbers of cars and the myriad trips in those cars to and from home, work, places of recreation, grocery stores, and so forth made traffic a universal subject of discussion throughout the country. Inner-city traffic also raised frustrations over parking—not only about the availability and location of spaces, but also about increased congestion and the competition for land to develop. Individual motorists, merchants, property owners, commercial fleets, taxis, and mass transit all have a need and responsibility for adequate parking. Congestion problems in core cities and across metropolitan areas in the U.S. have worsened in many places rather than improved, with motor-vehicle use doubling between 1970 and 1990.

Congestion problems were a major reason for developing some type of traffic control, and, by the mid-twentieth century, extensive highway construction. Prior to 1903 there were no rules for driving in American cities, but traffic controls of some type began to appear after the introduction of mass-produced cars. Initially controls emphasized the behavior of motorists, pedestrians, and the police. Cleveland had the first permanent installation of a red and green traffic control light in 1914; Detroit added a yellow caution light in 1917. However, getting accustomed to the new signs proved difficult for drivers used to having their own way on the road. In several cases, more experience with traffic problems led to better utilization of the streets and traffic patterns, but the rising use of the automobile created new traffic and safety practices.

One of the truisms about problems of motorized vehicle congestion was that building streets failed to keep pace with traffic demands. The solution, however, was often more roads and highways. This process of increasing hard-surface streets began in the late-nineteenth century to serve the needs of bicycle-, wagon-, and carriage-transportation, and continued into the twentieth century, primarily serving the needs of automobiles. The use of the streets as gathering places was threatened and then superseded by the needs and priorities of vehicular traffic. The Bronx River Parkway in New York City became the first highway to be designed exclusively

for the use of cars (completed in 1906, but only fully opened for traffic in 1924). In newer communities, pedestrian street activity sometimes was transferred to pedestrian precincts and paths or to shopping centers and malls.

The accommodation to the automobile through a remaking of the road system and the city in general came with a price, as had the introduction of the railroad and the streetcar before it. Building new roads and highways within cities damaged human and animal habitats; neighborhoods—especially those with little political clout—could be dislocated or even destroyed; and plant life and wildlife could be in endangered. Runoff from roads and highways—oil and grease, asphalt particles, rubber from tires, sand and salt from snow and ice buildup—all contribute to nonpoint pollution making its way into watercourses. Road building in general also increases runoff and limits the filtering capacity of soil. For their part, motorized vehicles proved to be a new safety risk as well as a health risk.

Suburbanization and the Automobile

Beside the various impacts on core cities, the automobile has had a great influence on extending the boundaries of urban areas on a scale and pace not experienced before. Fairly or unfairly, sprawl became synonymous with the automobile. While transportation of all types has had a major role in extending city borders, the automobile extended them much further and more randomly. American cities and suburbs became utterly dependent on the car for work, shopping, obtaining services, and recreation. In this setting, places of living, working, and shopping are disconnected—except for their common links to roads and highways.

Suburban communities themselves underwent physical changes with the introduction of the automobile. The new highways, delivery of electricity, and other technologies made it practical for developers to build new subdivisions far from metropolitan centers. Newer suburban communities also were designed for automobiles, not pedestrians, with drive-in markets, movies, and even churches. Retail establishments, office buildings, and numerous industries migrated to the suburbs from the core cities. The shopping mall, in particular, represented the clearest commitment to automobile traffic in the urban periphery.

Even suburban houses showed the imprint of the automobile as early as the turn of the century. The garage, especially, became an essential feature like the kitchen or the living room. Whether a house had a garage or a carport, with or without a long driveway, the automobile was built into the design of many homes and into the culture of the families who owned them.

Conclusion

Automobiles have become such a part of our lives that we rarely stop to consider in how many ways they impact and shape the world in which we live. The emerging “automobile society” of twentieth-century America resulted in dependence not only on a single form of transportation, but on petroleum and petroleum products, the creation of automobile-scaled landscapes, the evolution of new urban and suburban forms, vast commercial development, engulfing and ambient pollution, and more. At the same time, it is too simple to heap all the blame on automobiles for the ills of society without admitting the cars and the opportunities they provide have been embraced by generations of Americans. Choices come with consequences. The choices of producers, consumers, policy makers, and those carrying the burden of policy making, have planted square in the middle of our culture an abiding and altering technology like few others.

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