THE ENVIRONMENTAL TRANSITION TO AIR QUALITY

by Indur M. Goklany

ONE OF THE KEY ARGUMENTS used to justify the federalization of environmental regulation in the United States is the myth that before Washington intervened under the Clean Air Amendments of 1970, states were dragging their feet on improving air quality. According to some critics that foot-dragging proved that states could not be trusted to adopt adequate environmental policies, and forced Congress to impose national regulations. Federalization supporters contend that the states' alleged negligence was the inevitable outcome of a so-called "race to the bottom" in which states invariably sacrificed the environment in the inexorable competition for jobs and economic growth, and reduced net social welfare and economic efficiency.

But an analysis of trends in air quality refutes the contention. Focusing on traditional pollutants, that is, sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO), shows remarkable progress in improving air quality prior to federalization, particularly in the worst problem areas. Further, a review of social, economic, and technological factors that determine environmental quality shows that the order in which various indicators for each pollutant was controlled is consistent with the hypothesis of an affluence- and technology-driven "environmental transition."

Under that hypothesis, states are continually engaged in a "race to the top of the quality of life." At early stages of economic and technological development, such progress masquerades as a "race to the bottom" for environmental quality. That is because at those earlier stages society places a much higher priority on acquiring basic public health and other services such as sewage treatment, water supply, and electricity than on environmental quality, which initially worsens. But as the original priorities are met, environmental problems become higher priorities. More resources then are devoted to solving those problems. Environmental degradation is arrested and then reversed. And the race to the top of the quality of life looks more like a "race to the top" of environmental quality. In fact, there sometimes emerged the not-in-my-back-yard (NIMBY) situation, with states trying to avoid pollution whether the federal government is pushing them or not.

LONG-TERM TRENDS IN AIR QUALITY AND EMISSIONS

Before trying to understand the reasons for long-term trends in air quality, it is essential to establish when a substance in the air was first recognized or perceived by the general public and policymakers to be a pollutant that needed to be controlled because of its effects, real or imagined, on the public's health and welfare. That period can be called the "period of perception" [p(P)]. Before the p(P), one should not expect that state or local policymakers would have required, or private entities would have voluntarily undertaken, any measures to specifically control that substance. Thus, pre-p(P) trends tell us little about those policymakers' or entities' desire or ability to control pollution.

For example, at least as early as the beginning of this century, smoke and dust were widely perceived to be air pollutants. Well before federalization, substantial progress was made in cleaning them up. Pittsburgh, a city once synonymous with smoke, is a case in point (see Figure 1). (All figures are at the end of this article.)

But for the other traditional air pollutants, the notion that they could also be detrimental to human health and welfare was accepted much later. For example, sulfur dioxide (SO_2) was seen as a substance in need of control only after serious air pollution events caused deaths in Donora, Pennsylvania, in 1948 and London in 1952. Thus the p(P) for SO_2 can be fixed at about 1950. Any SO_2 reductions before that period would necessarily have been caused by purely economic factors, or chance, because sources of SO_2 also emitted smoke, which was being controlled.

As another example, consider the case of ozone and volatile organic compounds. Although Californians had recognized in the 1950s that ozone, a "secondary" pollutant (and its precursor, VOC), were substantially implicated in their smog problems, most jurisdictions did not see them as threats until the late 1960s or early 1970s. Thus, one should not expect those jurisdictions to have instituted controls before the late 1960s or later.

Table I summarizes various milestones for three sets of indicators for each traditional pollutant based upon detailed analyses of historical trends in regulation, and in aggregate national emissions and air quality. For each pollutant, the table

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Table I: Milestones and Transitions for Various Pollutants and Indicators

Substance	Period or Year When Substance Was: Recognized or perceived as a pollutant [tp(P)]	First federally regulated [t(F)]	Worst Year(s) or Period of Transition (Nationally, Unless Noted Otherwise): Indoor air quality	Outdoor air quality	Emissions (E)	E/GNP[1]
PM	<1900	1971[2]	<1940	<1957	1950[3]	1940s or earlier
SO_2	Approximately 1950	1971[2]	<1940[6]	Early to mid-1960s	1973	1920s
CO	Approximately late 1950s[4]	1967[5]	<1940	Mid-1960s (?), but not after 1970	1970-71	1940s or earlier
VOC/O_3	CA, 1950s	[7],1971[2]	NE	CA,1966-67	NE	NE
	Elsewhere, 1960s or later	1967[5]	<1940[6]	Elsewhere, mid- to late 1970s	1967	1930s
NO_x	CA, 1950s Elsewhere, 1960s or later	1971[2]	<1940, secondary peak around 1960[6]	1978-79	1978	1930s

1 The peak in this leading indicator shows the latest time by which "cleanup" had begun either through deliberate actions or by happenstance. 2 The Clean Air Amendments of 1970 was signed on the last day of 1970, but most federal regulations went into effect later. 3 For PM-10. 4 CO: long known to be deadly indoors, but its status as an outdoor air pollutant was recognized much later. 5 Model Year 1968 for automobiles. 6 Not generally recognized by the public or policymakers as needing remediation indoors. 7 Because federal vehicle emissions were borrowed from, and went into effect after, California's, federalization did not have any effect until after the 1970 amendments were signed; NE = "not estimated."

indicates p(P); when federal regulations first went into effect [t(F)]; and the year(s) when each indicator peaked or went through its "period of transition," [p(T)]. Finally, Table I indicates when emissions per GNP peaked for each pollutant.

For constructing Table I, "indoor" air quality was derived from 1940 through 1990 using, as a crude proxy, residential combustion emissions per occupied household (Figure 2). The outdoor air quality trends were developed by stringing together, for each pollutant, data from EPA (or predecessor agencies') reports on air quality trends, Council on Environmental Quality's annual reports (e.g., Environmental Quality), and the Statistical Abstracts of the United States. These publications usually provide data for several years at a time. By combining several of these series, it is possible to construct a longer series, going back to 1957 for total suspended particulates (TSP) (Figure 3) and 1962 for SO_2 (Figure 4). But for the other pollutants, the data are of more recent origin. Finally, the national emission estimates used to construct Table I came from EPA's 1994 emissions trends report, which provides data from 1900 to 1994 for SO_2 (Figure 5), VOC (Figure 6) and NO_x, and from 1940 for PM and CO.

Table I shows that for each pollutant, the period of transition depends upon the precise indicator (i.e., whether it is indoor or outdoor air quality, or emissions). It also shows that environmental quality had begun to improve substantially before federalization, particularly for pollutants that were generally recognized at the time of federalization to be public health problems, and especially in the areas where their levels were the highest.

For instance, the 1960s saw relatively rapid progress in urban air quality for particulate matter and SO_2, the pollutants most closely associated with excess mortality during the killer episodes of the late 1940s, 1950s, and 1960s (Figures 1, 3, and 4). A 1973 EPA analysis of national air quality trends showed that between 1960-63 and 1968-71, the four-year average of the annual concentrations for total suspended particulates (TSP) fell at 66 urban stations, went up at 8, and showed no change at 42. Over the same periods, the average number of urban stations exceeding the future annual primary National Ambient Air Quality Standard (NAAQS) dropped from 81 percent to 63 percent.

Similarly, between 1964 and 1971, annual average SO_2 concentrations declined at 19 urban stations, went up at 1, and showed no change at 12. Between 1968 and 1971, the corresponding figures were 42, 3, and 17, with levels at 33 stations being too low to detect meaningful trends. Similarly, oxidant air quality, which was considered to be a problem foremost for California, particularly in the Los Angeles area, had been improving in that area since the 1965-67 period.

The Clean Air Amendments of 1970 were signed on the last day of that year, and there were time lags between the signing of the law, the formulating of regulations to enforce the law, and final compliance with those regulations. Thus most of the improvements between the mid-1960s and 1971 that were uncovered in the EPA analysis would have occurred absent the 1970 Amendments. Hence, there is no empirical basis for blanket statements that state and local governments were failing to control air pollution before federalization. Moreover, the slopes of the trends for the various indicators do not show more rapid declines in emissions or improvements in air quality once federalization became effective (Figures 1-6), except for motor vehicle emissions. But, in fact, the federal motor vehicle emission control program was, itself, derived from California's program, and enacted, in part, not because states were doing too little, but because auto companies and Congress feared some might do too much by passing separate and inconsistent laws.

WHEN DID "CLEANUP" COMMENCE?

In a society whose economy and population are expanding, emissions per gross national product and emissions per capita can serve, to some extent, as leading environmental indicators. Unless there is a sustained decline in those leading indicators, there will be no eventual downturn in emissions, though air quality may well improve. Accordingly, an examination of whether—and when—these leading indicators peaked, indicates broadly the latest time by which "cleanup" efforts may have commenced.

Of particular importance are changes in national emissions per GNP (E/GNP), which measures the aggregate effect of technological change upon all of that society's activities responsible for that pollutant's emissions. E/GNP may, for instance, decrease if old processes are replaced by new, more efficient technologies as a result either of economic factors or of regulatory requirements. Alternatively, it may increase if the structure of the economy changes to include more energy- or pollution-intensive activities. Emissions per GNP peaked in the 1920s for SO_2 (Figure 5), the 1930s for VOC (Figure 6) and NO_x, and the 1940s (or earlier) for PM and carbon monoxide (Table I). Eventually, those reductions were followed by reductions in total emissions –in 1950 for PM-10, 1967 for VOC, early 1970s for CO, 1973 for sulfur dioxide, and 1978 for NO_x (Table I).

Clearly, for SO_2, VOC and NO_x, clean up—a term that must be used cautiously here because one cannot clean up what one does not realize is dirty—had begun long before a substance was recognized as a pollutant [t(P)], and certainly before federalization.

DECIPHERING THE TRENDS–THE ENVIRONMENTAL TRANSITION

There is a relentless logic to Table I: improvements in the indicators of air quality for pollutants known or perceived to cause the largest public health impact came before those for the "lesser" pollutants, in indoor air quality before outdoor air quality, in outdoor air quality before total emissions (for primary pollutants), and for primary pollutants before secondary pollutants.

It is possible to construct a framework to help explain the logic underlying Table I, and the order in which the various peaks occurred for each pollutant and indicator. This framework, represented graphically in Figure 7, is based upon the hypothesis that society is on a continual quest to improve its quality of life, which is determined by numerous social, economic and environmental factors. The weight given to each determinant is constantly varying depending upon a society's precise circumstances and perceptions. In the early stages of economic and technological development, which go hand in hand, a society attempts to improve its overall quality of life by placing a higher priority upon increasing affluence than on other determinants. Such priorities might mean that a society tolerates some environmental degradation. Greater affluence provides the means for obtaining basic needs and amenities (e.g., food, shelter, water, and electricity) and reducing the most significant risks to public health and safety (e.g., infectious and parasitic diseases, and child and maternal mortality).

As a society becomes wealthier, progress is made on such priorities but environmental degradation increases. Thus, environmental problems move to a higher priority on society's list of unmet needs; that is, environmental quality becomes a more important determinant of the quality of life. Generally, a society will enshrine its priorities into laws and regulations unless a priority is self-executing. Even in such a case laws or regulations might be made for the sake of symbolism, as a statement about priorities. Moreover, the wealthier the society, the more it can afford to research, develop, and install the technologies necessary for a cleaner environment. Consequently, a society goes through an "environmental transition," and environmental degradation peaks. Following that, additional economic and technological development, instead of worsening environmental quality, actually improves it. Once past the environmental transition, depending upon the precise set of circumstances surrounding the costs of action and inaction, environmental degradation might continue to be reduced, stay more or less constant, or, if degradation has been sufficiently reduced, even rise slightly.

Because American society has become progressively wealthier and technologically more advanced over the last century, an environmental transition manifests itself as a peak in a post-p(P) temporal trend line for environmental degradation. Thus, we see in Figure 7 a simplified representation of each of the Figures 1 through 6 for the post-p(P) period. In some instances, for example, indoor and ambient air quality for TSP (Figures 2 and 3), there are no apparent peaks corresponding to any transitions. But this is because the data needed to construct the trends are available only for post-transition [post-p(T)] periods.

Each transition is reinforced by society's technology-assisted evolution from an agrarian, to an industrial, to a knowledge- and service-based economy. That evolution, in turn, causes emissions per GNP to first increase and then decrease (see Figures 5 and 6). The changes are further amplified because the economic and demographic influences of the polluting sectors of the economy also rise and fall as their relative contribution to national employment and GNP waxes and wanes in consonance with the economy's evolution. In a democratic society, this eventually results in increasingly tougher environmental policies in a postindustrial era. Thus it is hardly surprising that increasingly more stringent regulations on industries and sectors such as mining, timber, and agriculture can be seen today and will continue to be seen in the future as their economic and demographic power diminishes.

Accordingly, the timing of an environmental transition for any pollutant should depend upon the general level of affluence, state of the technology, pollutant effects relative to other societal risks, and affordability of control or mitigation measures. But these factors are not independent: affluence helps create technology and vice versa; knowledge of a pollutant's effects is itself a product of technology; and affordability depends upon affluence and technology. In short, an environmental transition should ultimately be determined by affluence and technology.

Table I is, indeed, consistent with the environmental transition hypothesis. With greater prosperity and the advent of new technologies in the early decades of this century, the worst problems—and the easiest to address—were dealt with first. Families voluntarily cleaned up their personal environment, that is, their households, of the most obvious problems—smoke and, to some extent, CO—before anything else. They started switching from wood and coal to gas, oil, and, sometimes, electricity for cooking and home heating. The change also benefited their immediate neighborhoods.

In addition, industrial and commercial establishments invested in new technologies and practices to improve the combustion efficiencies of their boilers and other fuel-burning equipment to reduce smoke partly because smoke signaled poor efficiency, that is, needlessly higher fuel bills, and partly because it testified to their civic conscience. Moreover, since SO_2 and VOC are associated with solid fuel combustion, it also reduced SO_2 and VOC indoors (Figure 2) and helped set in motion the long-term declines in their E/GNP (Table I, Figures 5 and 6), although neither was generally perceived to be particularly harmful at that time.

Next, attention turned to outdoor air. Once again, the first target was smoke because it was the most obvious and an acknowledged pollutant. New technologies and prosperity helped move the industrial and commercial fuel mix from coal and wood toward oil and gas, generally increasing fuel efficiencies across all economic sectors. As a result, soon after World War II, if not earlier, most urban areas had gone through their environmental transitions for smoke and PM (Table I).

With greater prosperity, better health, and reduced mortality, the risks of other outdoor air pollutants became easier to infer or detect. In the years following World War II, deadly air pollution episodes occurred on both sides of the Atlantic, which were ascribed to PM, SO_2, or both. Thus, transitions for PM and SO_2 air quality came next, followed in time by CO and O_3. That the transition for NO_x came last is fitting for a pollutant that was never ranked very high in adverse effects at measured ambient levels, and was also the most expensive to control. This is in large part because many technologies for improving fuel efficiency and reducing smoke, unburnt carbon in ash (both constituents of particulate matter), and CO inadvertently increased NO_x emissions.

A RACE TO THE BOTTOM, OR TO THE TOP?

The notion that states participate in a race to the bottom, relaxing air pollution requirements and reducing net state welfare, is critical to any rationale for federalizing environmental control. A corollary to the race to the bottom hypothesis is that before federalization, there should have been no improvements in air quality anywhere (except by accident or happy economic circumstance). But, in fact, a number of trends show that there was not a race to the bottom.

First, there were broad improvements in air quality for several pollutants before federalization, and the race, if any, seems to have been in the opposite direction. The pre-federalization improvements in air quality are particularly pronounced for those pollutants associated with—and in the areas where they were most likely to create—the largest public health risks. For instance, ambient air quality for TSP and SO_2, the pollutants associated with the killer pollution episodes, had gone through their environmental transitions nationally before the federal government began regulating those pollutants (Table I; Figures 3 and 4). Those improvements were especially noticeable in urban areas (see, e.g., Figure 1). Similarly, CO had either gone through, or was on the verge of its own, transition before federalization (Table I).

In addition, oxidants/O_3 had gone through a transition in California, a state where they were widely recognized to be a problem, before federalization had any real impact in that state. Outside California, few jurisdictions made much effort to reduce oxidants because most were unaware that those pollutants also posed a problem for them until just before—or, in many cases, after—federalization. Perhaps the best evidence for this is the inability to construct a national composite for ozone or oxidant air quality before the early 1970s, because of insufficient monitor coverage outside California. Thus, the relatively tardy response to ozone/oxidants outside California was due not to a race to the bottom, but because states were not racing to solve problems they did not know they had.

Second, in a trend that is inconsistent with any race to relax standards, county and state air programs grew significantly during the 1960s. Between 1960 and 1970, the number of county programs increased from 17 to 81, and state programs from 8 to 50. Even if those programs were window dressing—and Figures 3 and 4 suggest they were not—their existence would, at the very least, send a signal to industries considering moving into particular states that contradicts what would be expected in a race to the bottom scenario. An alternative explanation for the trends depicted in Figures 3 and 4 is that air quality improved despite what many legal scholars contend were poorly written and badly enforced laws that made federalization necessary. In either case, Figures 3 and 4 demolish the myth that federalization was necessary to have progress in the air.

A third trend that contradicts the race to the bottom scenario was that standards for density of smoke emissions and process weight emissions were progressively tightened in many jurisdictions nationwide before the 1970 Clean Air Act. That is to say, those jurisdictions were in effect bidding standards up rather than down—the very antithesis of either a race to the bottom or a race to relax standards. Those tightenings were accompanied by substantial improvements in efficiencies of dust-collection (Figure 8). For instance, overall dust-collection efficiencies for power plants nationwide were estimated to have increased from 40 percent before 1940, to 75 percent in 1940 and 95.5 percent by 1966. In other words, emissions for a ton of coal burnt in the average power plant in 1965 were only 7.5 percent of what they were pre-1940. In fact, a 1970 National Air Pollution Control Administration report suggested that the limited acceptance of the American Society of Mechanical Engineers' 1966 model air pollution control regulations for fuel burning equipment may partly have been because its "control requirements...are generally lenient compared to other modern regulations" and that "many new industrial plants install equipment for purposes of eliminating all visible plumes, even if not required to do so" because they constituted good public relations and reduced complaints.

Fourth, the federal preemption of motor vehicle emission standards outside California indicates the automobile industry and Congress were concerned not about a race to the bottom or a race to relax standards but a movement toward greater control. Federal preemption was designed, among other things, to forestall such a situation.

During the industrial era when jobs and prosperity often signified air pollution, the quest for a better quality of life may have seemed like a race to the bottom of environmental quality. But in today's postindustrial era, prosperity is often inversely correlated with pollution. Now the service sectors account for three of every four nonfarm jobs. Accordingly, many jurisdictions maximize jobs by catering to the needs of the service sectors and their employees while actively discouraging polluting industries altogether. For instance, Florida and many California communities have effectively banned oil drilling off their coasts to protect tourism and commercial fishing. In essence, those communities are maximizing their quality of life by adopting a "not-in-my-backyard" (NIMBY) stance.

FROM A "RACE TO THE BOTTOM" TO NIMBY

The apparent existence of both the race-to-the-bottom and the NIMBY phenomena can be explained by an affluence- and technology-driven environmental transition caused by a "race to the top of the quality of life" (Figure 7). During the early phases of economic and technological development (or if the net costs of controlling that pollutant are perceived to be excessive), the "race to the top of the quality of life" may superficially resemble a "race to relax" or a race to the bottom of environmental standards.

But once a society gets past the transition and environmental factors improve, the race to the top of the quality of life might drive the environmental degradation trajectory in one of several different directions. If the benefits of control for the society are substantially less than its costs, or if the costs are shifted to others while benefits are retained, environmental degradation will be driven down further. That is to say, society will move toward greater cleanup, as indicated by the solid post-transition line in Figure 7. In effect, the race to the top of quality of life would look like a race to the top for environmental quality, and masquerade as a NIMBY situation. Thus, the early apparent race to the bottom and the NIMBY effect are, in fact, two aspects of the same phenomenon. But the former occurs before, whereas the latter occurs after, an affluence- and technology-driven environmental transition, and only if perceived benefits far exceed perceived costs.

However, if the perceived social and economic costs of environmental improvement are in the same ballpark as the perceived benefits that might occur if costs cannot be shifted to someone else, then the precise trajectory—whether it continues downwards but not as steeply as in the NIMBY case, goes up, or stays more or less constant—will depend upon a more careful balancing of the costs (C) and benefits (B). The dashed line in Figure 7 depicts a case where, because the environment has improved sufficiently, perceived benefits no longer exceed perceived costs and, therefore, environmental degradation swings upward, ending in the "C/B Region." Such an upswing in environmental degradation could occur in a number of different situations. New information or changes in societal values and attitudes might cause a society to conclude that past control efforts, for whatever reason, went too far or were unnecessary. Perhaps limits of clean technology have been reached for the affected activity, there are no substitutes for the activity, and additional activity would necessarily end up having a greater impact. Or perhaps, for whatever reason, society perceives that scarce financial and human resources should be allocated to other problems, as the particular environmental problem seems to have been contained.

The timing of a transition depends upon the specific pollutant or indicator and the relative social, economic, and environmental costs and benefits of addressing that pollutant or indicator. Accordingly, it is possible for a society, group, or individual to be simultaneously to the left of the environmental transition for one pollutant but to the right for another. Hence, it is quite rational and not unusual to oppose, say, transportation control plans on one hand and to support stricter controls on incineration on the other.

SYNTHESIS AND DISCUSSION

As indicated by trends in emissions per GNP—leading environmental indicators in a growing economy that also double as measures of technological change—cleanup commenced in the 1920s for SO_2, by the 1930s for VOC and NO_x, and, at least, by the 1940s for PM and CO (Table I). The first improvements came from voluntary, market-driven measures driven by the desire for—and the ability to purchase—personal and household cleanliness and comfort among the rich and middle class, and by economic self-interest. Households, industry, and commerce started switching to cleaner fuels and more efficient equipment and practices for combustion and other processes. Those actions improved indoor air quality and, eventually, outdoor smoke went through its transition in urban areas shortly after World War II, if not earlier. But as the worst risks to health and safety were reduced, the risks of PM and SO_2 became more evident and more easily inferred. Both substances were implicated in a series of deadly post-World War II air pollution episodes on both sides of the Atlantic. Local and state governments became more active in controlling those pollutants. Thus, transitions for PM and SO_2 air quality came next.

Empirical data showing that the nation had, in the aggregate, gone through its environmental transitions for smoke, TSP, SO_2 air quality, and stationary source CO emissions before federalization directly contradicts any race-to-the-bottom rationale for federalization, as does the timing of the transition in oxidant air quality in California (Table I). In fact, that rationale is intrinsically flawed: if there is any race, it is not to the bottom of environmental quality, but to the top of the quality of life.

Without federalization, there is every reason to believe that air quality would have continued to improve, but perhaps not as rapidly in some areas. But as experience with, and the savings generated by, emissions trading schemes have shown, the command-and-control regulations that drove the additional improvements have exacted a higher price than necessary, and the total current risk to public health would have been lower if there had been a conscious effort to maximize risk reduction for the total costs incurred by society.

Considering that the nation and the states are today substantially to the right of the peaks of their environmental transitions for traditional air pollutants, it is unlikely that devolution would lead to a rollback of the gains in air quality. On the other hand, given the past improvements in air quality and given that the easy—as well as many tough—reductions have already been made, further air quality improvements may not be sustainable if they come at the expense of the broader quality of life.

To ensure that the two go hand in hand, emissions trading should be expanded to allow trades between old and new sources. The pollutant-by-pollutant approach should be replaced by one that focuses on reducing overall risks to public health and welfare at local and regional levels. Control of interstate pollution should be negotiated between affected states, with the downwind states being free to accept, in lieu of additional control of specific air pollutants, other reductions in risk to public health and welfare funded by the upwind (polluting) states if the former deem that would provide greater benefits to their populations. Such risk reduction should not be limited to efforts to reduce risks just from air pollution or, for that matter, other forms of pollution. They could include, for instance, such measures to improve health services and delivery as sponsorship and funding of wider screening for cancer, heart disease, or blood pressure, or vaccinations or other routine-but-underutilized health care procedures.

For intrastate pollution, the federal government should step back from its role as the micromanager of air pollution control and, instead, enter into a more equal partnership with the states. Under such an approach, the federal government would set idealized goals, and states would determine their own attainment schedules and control measures for pollutants produced within, and affecting, their own jurisdictions. That is only appropriate, because the tradeoffs that have to be made to improve their overall quality of life, of which environmental quality is only one facet, necessarily depend upon many location-specific factors, and states will be the major winners or losers from their own actions (or inaction). Because many of the determinants of the quality of life are unquantifiable, optimizing the quality of life should be left to each state's political process. To echo Winston Churchill, it is, like a democracy, the worst method, unless one considers all the others.

CONCLUSION

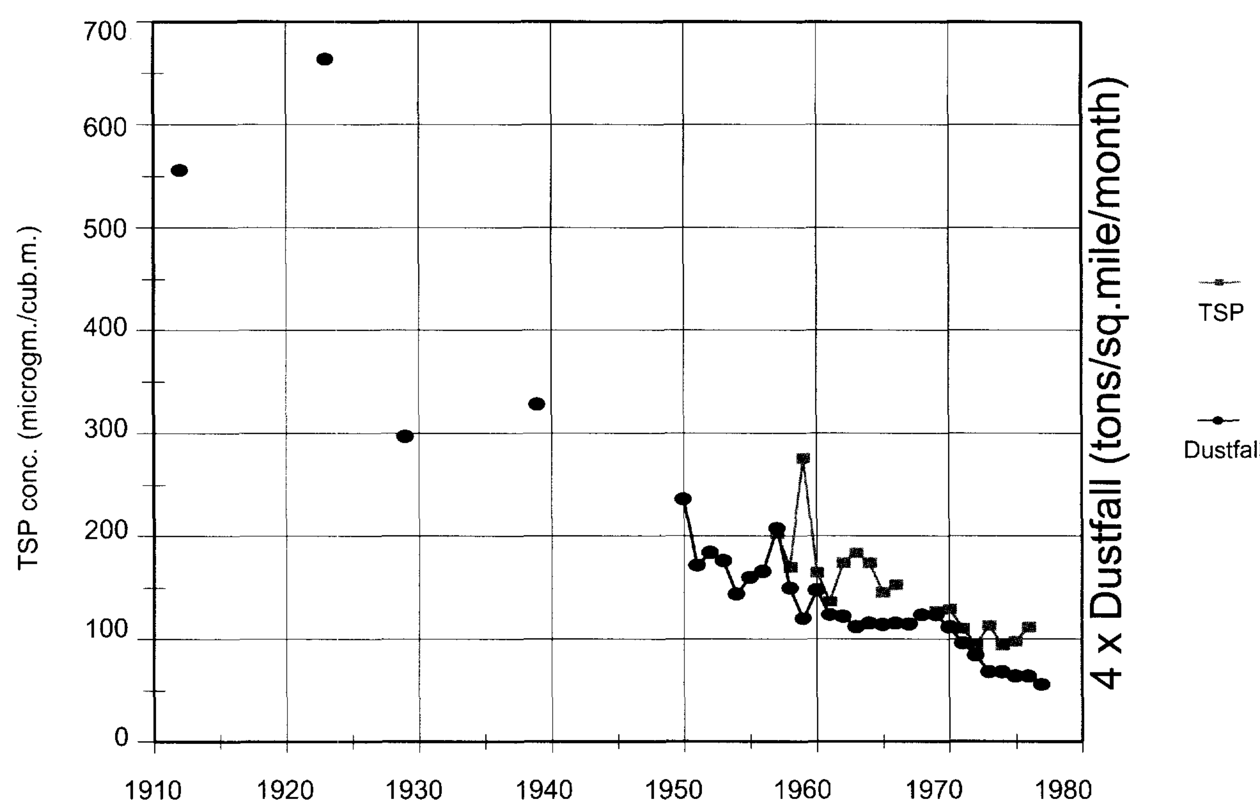
Prosperity and technology were once responsible for air pollution. Today they are essential for its cleanup. Their transition—from problems to solutions—began toward the latter part of the last century with the emergence of new, clean energy sources and more efficient combustion technologies, and gathered steam through this century. And through the decades, one by one, the various pollutants were brought under control, each being forced through an environmental transition. As if in accordance with a grand design, the most obvious and the easiest-to-control problems were addressed before others, with each pollutant's transition being determined by factors dependent ultimately on prosperity and technology. And contrary to conventional wisdom—and the notion of a race to the bottom—empirical data show that much of this improvement came before federalization, or the implementation of the regulations which would eventually give it force.

The seemingly logical progression in environmental transitions for air pollution in the United States should not be mistaken for predestination. The transitions resulted from continually increasing levels of affluence and technology. But, as the broad sweep of history suggests, neither are inevitable. America was fortunate that its political and legal system supported the institutions that fostered economic growth and technological change. For the same reasons, many of the world's developed nations have gone through similar environmental transitions for various air pollutants over the last several years. Other nations, such as the erstwhile centrally planned economies, which lacked such institutions, have had the worst of all worlds—they are poorer and their environment is wretched. Their problems were further aggravated by the absence of democracy that provides a powerful incentive to decisionmakers to constantly monitor and improve the quality of the ordinary citizen's life.

Often disdaining—if not actively discouraging—economic growth, and sometimes rejecting new technologies, many environmentalists hold that lifestyle changes are essential to a cleaner environment. But economic growth and new technologies were indispensable to bringing about the various environmental transitions without which air quality and the quality of life would have been even poorer than it was a generation or more ago. The need for fiscal resources and new technologies is not diminished either in the United States or worldwide.

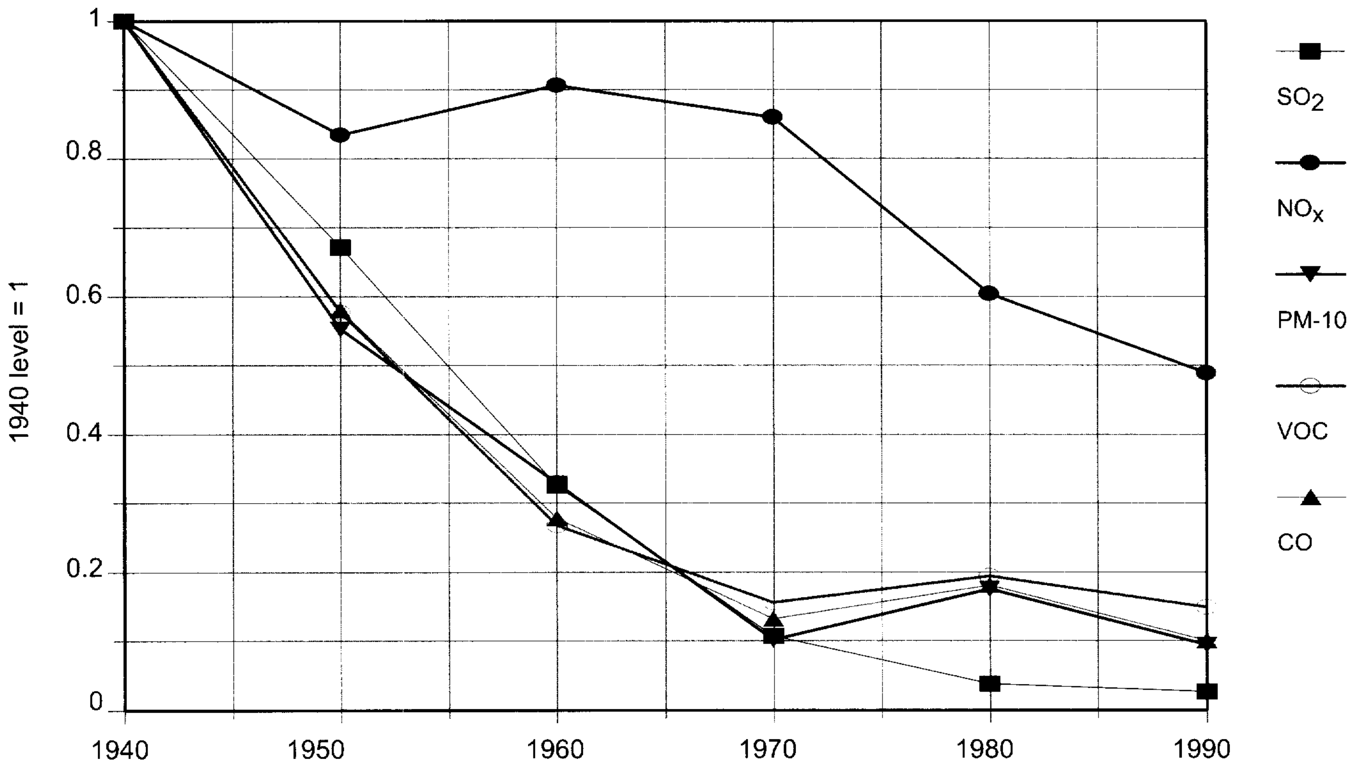
A 1997 United Nations Development Program study estimated that $300 billion to $600 billion is needed worldwide for pollution control projects by the year 2000. As the world's future environmental problems become more challenging, there will be an even greater demand for fiscal resources to research, develop, and implement new technologies to bring about environmental transitions for those problems. Thus, one of the keys to environmental progress is to nurture the institutions that bolster economic growth and technological change in order to move societies further to the right toward—and beyond—their environmental transitions.

Figure 1 **Pittsburgh, Dustfall, and Total Suspended Particulates 1912 to 1977**



Source: Cliff I. Davidson, "Air Pollution in Pittsburgh: A Historical Perspective," *Journal of the Air Pollution Control Association* 29 (1979): 1035-1041.

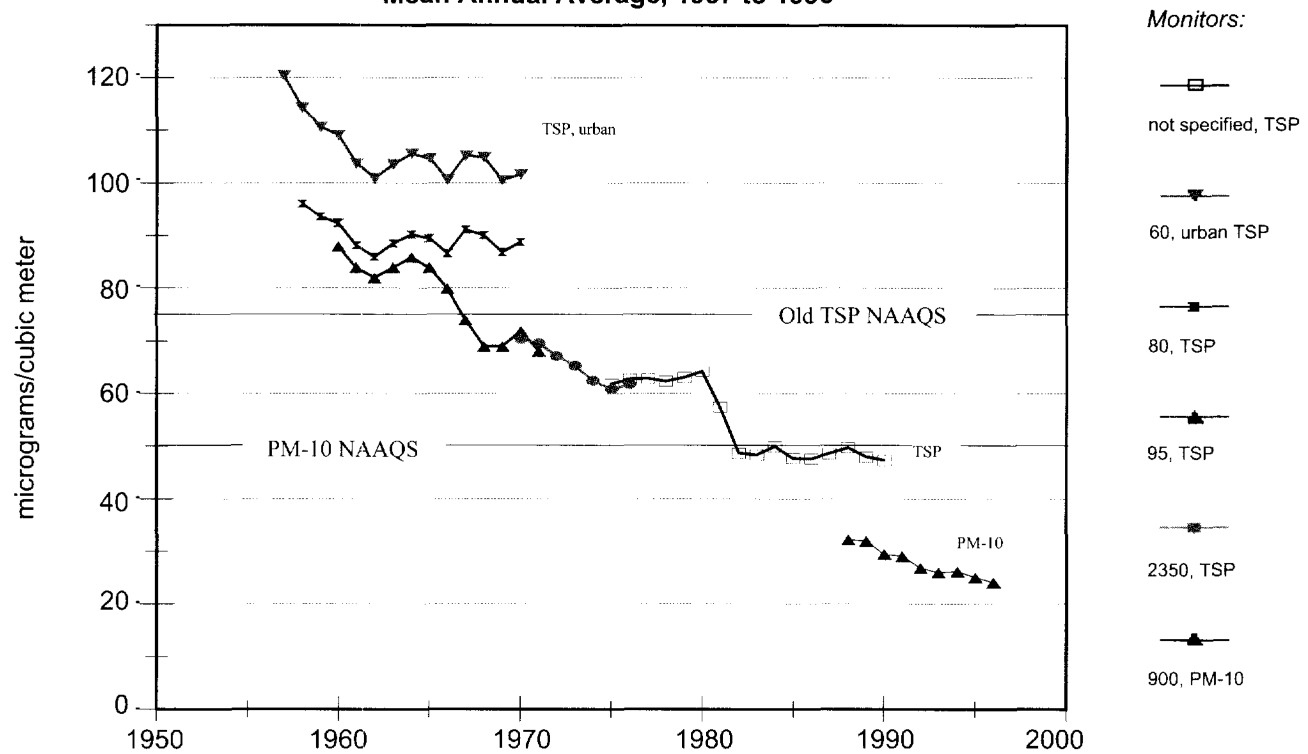
Figure 2 **Indoor Air Quality, 1940 to 1990 (using as a proxy residential emissions per occupied housing unit)**



Sources: *Historical Statistics of the United States* 1975; EPA 1995; *Statistical Absract* 1992.

Figure 3

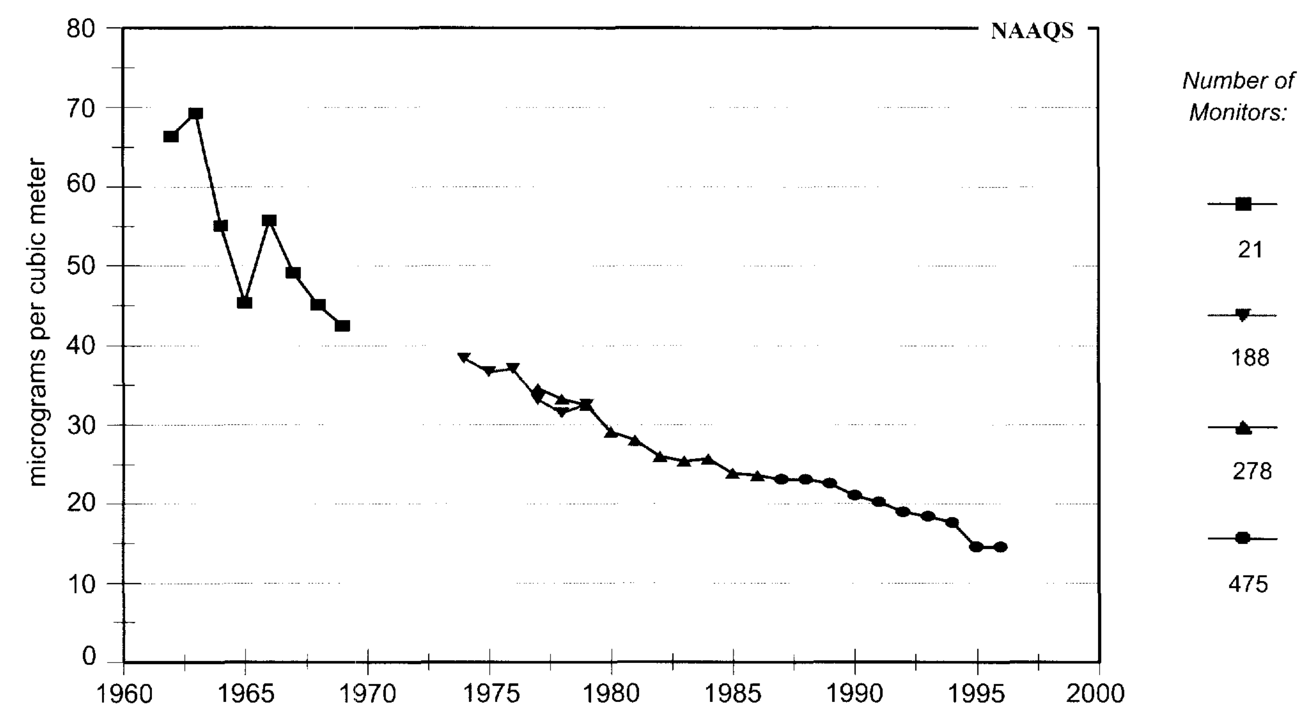
TSP and PM-10
Mean Annual Average, 1957 to 1996



Sources: Council on Environmental Quality 1971, 1979, 1981, 1991; EPA 1990, 1998.

Figure 4

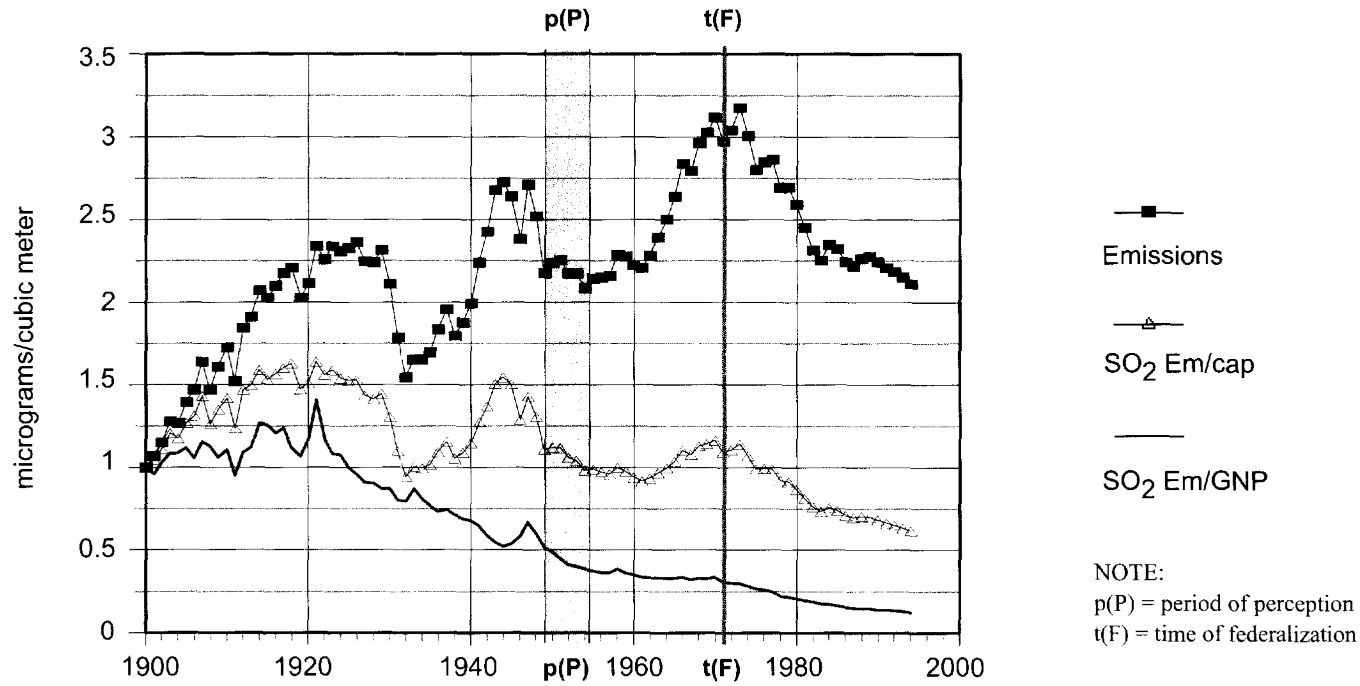
Ambient SO_2 Concentrations
Mean Annual Average, 1962 to 1996



Sources: Council on Environmental Quality 1971; *Statistical Abstract* 1971; EPA 1998.

Figure 5

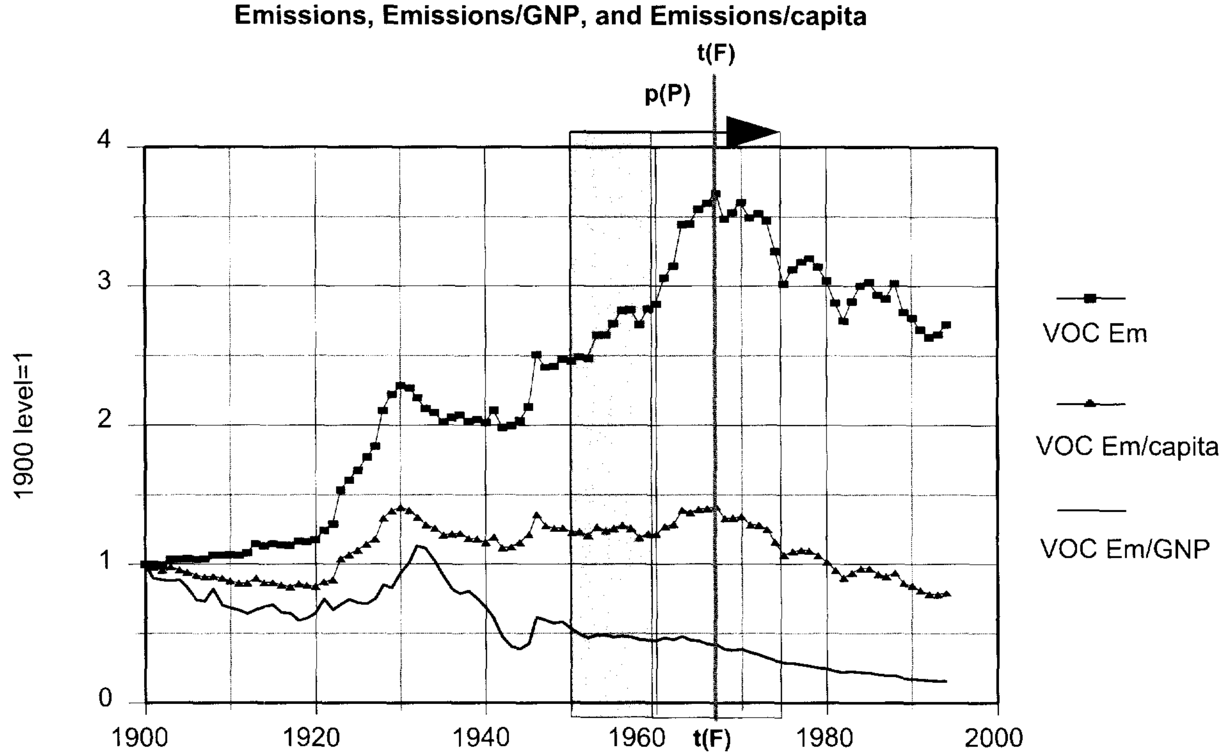
Sulfur Dioxide, 1900 to 1994
Emissions, Emissions/GNP, and Emissions/capita



Sources: EPA 1995; *Historical Statistics of the United States* 1975; *Statistical Abstract* 1995, 1996.

Figure 6

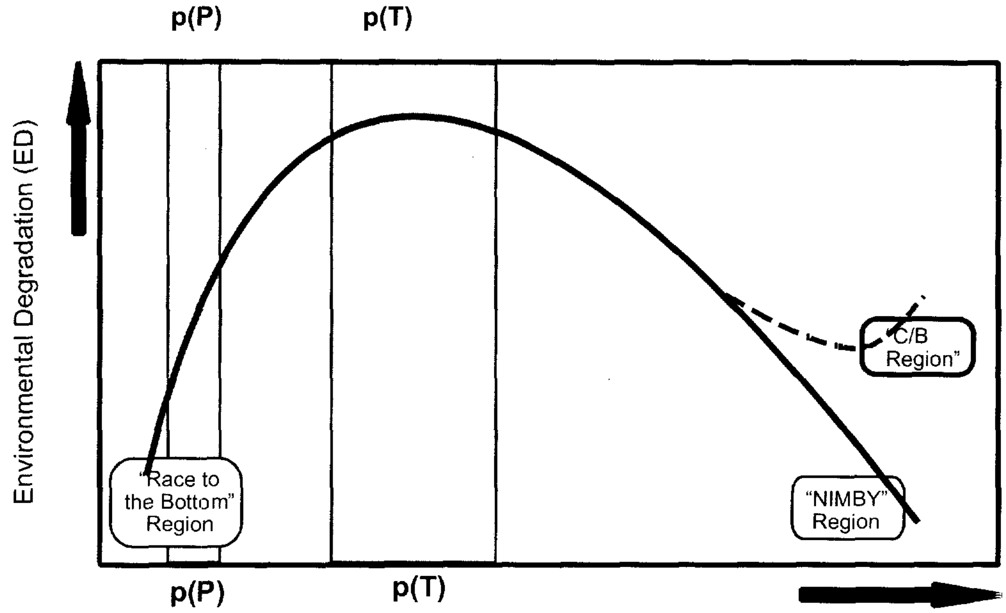
Volatile Organic Compounds, 1900 to 1994
Emissions, Emissions/GNP, and Emissions/capita



Source: EPA 1995; *Historical Statistics of the United States* 1975; *Statistical Abstract* 1995, 1996.

Figure 7

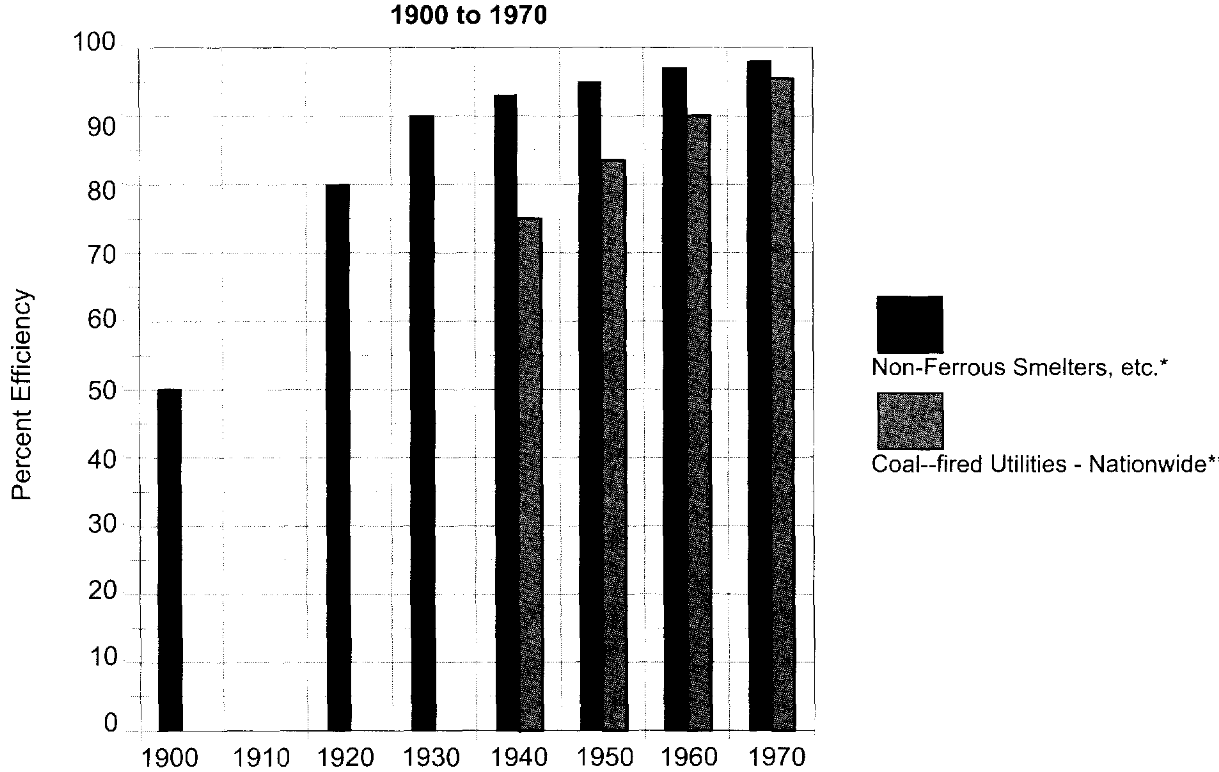
The Environmental Transition



Source: Indur M. Goklany, *Clearing the Air: The True Story of the War on Air Pollution*, to be published by Cato Institute.

Figure 8

Dust Collection Efficiency 1900 to 1970



Source: Tarr 1996; Moore 1966.
*for the Hudson-Raritan basin
**the 1970 figure is actually for 1966