acting population systems as herbivore and plant, parasite and host, predator and prey, and interspecific competitor systems. The real significance of this mechanism for population regulation lies in the fact that it has its foundation in evolution. Population regulation by genetic feedback supports Emerson's (*36*) view that evolution in natural populations is toward homeostasis (balance) within populations, communities, and ecosystems.

Students of population ecology and especially of parasitology and epidemiology generally accept the fact that evolutionary trends in relationships of parasite and host are toward balance. The deductive basis for this generalization rests on the ecological principle that disharmony results in serious losses to both parasite and host. Large numbers of fatal infections in the host population eventually lead to host extinction which in turn brings about the extinction of the parasite. The success of any living population is measured by its relative abundance and distribution as well as its ability to survive in time.

Homeostasis, in herbivore-plant, parasite-host, and predator-prey species and among other community members in general, results in improved survival of the community system. The evolved balance in supply and demand achieved by the feeding species and its host establishes a sound economy for the community. This, of course, enables the community to make effective use of the resources available to it.

Increased species diversity in a community is due in part to community homeostasis. The genetic integration of interspecific competitors which makes possible the use of the same resource by competing species and enables them to occupy the same niche contributes to greater species diversity. The increased network of interactions within the community, resulting from a greater number of species present, further contributes to community homeostasis.

With more knowledge concerning the regulation of natural populations, man will be in a better position to control the pests on his food crops and the parasitic diseases of mankind. This will also help conserve the millions of living species which are vital for the functioning of the vast living system of which he is a part.

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Air Pollution: Time for Appraisal

Abel Wolman

Some three-quarters of a century ago, Sir Edwin Chadwick of London, England, proposed a project "to draw down air, by machinery, from the upper couches or strata of air and distribute it through great cities, like the Metropolis." He was prompted to suggest this program "on the repeated sight of a great blanket of fog spread over the Metropolis" and even suggested the formation of a "Pure Air Company, which would engage to draw the air from a suitable height . . . and distribute it into houses . . . and do it with a profit, at a very low rate" (*1*).

Needless to report, the company was not formed. London continues to this day to struggle with the fog and its consequences, despite repeated legislative proposals to control it. In the Los Angeles area, however, similar proposals for one form or another of forced drafts have found their way into scientific journals in the 1960's, again without serious attempts at implementation.

The awareness of the air pollution problem has been intensified in the official and public mind by the dramatic episodes in Donora, Pennsylvania, the Meuse Valley in Belgium, in London, and in Los Angeles. In the United States, this dramatic interest was translated into federal legislation in 1963 and further clarified by the Clean Air act of 1967. Simultaneously, official evaluations have come off the press in large numbers. It may therefore be assumed, with ample justification, that the air is variously polluted, that the public is alerted to its significance, and desires that the moves toward cleaner

The author is emeritus professor of sanitary engineering and water resources development at Johns Hopkins University, Baltimore.

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air be accelerated. We are now implementing corrective measures, moving toward the establishment and enforcement of criteria, evaluating costs and benefits and translating scientific and technical knowledge into social advantage. At this stage, one is confronted with more problems than are generally found in policy which has received national acceptance.

Recently, at a conference in Baltimore, Donald F. Proctor posed three pertinent questions suggesting broadly the areas to which serious consideration is now due (*2*). They are not all-inclusive, and will be examined further:

1. Are the strong pressures being brought into play in opposition to one or another of pollution control measures justifiable?
2. Among the many sources of air pollution, which are the ones most urgently in need of and susceptible to attack?
3. What are some of the avenues of research which may be most helpful?

Throughout his paper, he joins many other investigators in the plea that, while we pursue inquiries in many significant unresolved areas, we do not lose sight of the major objective of cleaning the air as rapidly as possible. Almost all public discussion, whether lay or scientific, points to the retarding effect which research has upon action. If research actually impedes administrative regulation, it is futile to discuss what blocks exist to sane, logical, and economical regulation and how these may be rapidly removed. I suggest that various aspects of air pollution abatement warrant scrutiny. Solutions to some issues will undoubtedly take time. This fact does not make the search for answers any less important and may delay the application of ill-considered or capricious regulatory measures.

Nonbiologic Effects of Air Pollution

While we are attempting to improve the quality of the atmosphere and while we may accept the fact of serious damage to materials, structural and otherwise, it is not amiss to suggest that some more realistic estimate of annual damage is overdue. One repeatedly sees an estimated damage figure of $11 billion a year. Should not the source and accuracy of such billions be tested by normal scientific means? I hardly need the cost item to justify considerable action, but can the figure be more adequately documented?

Biologic Effects

Three years ago, I pointed out (*3*) that one of the major deficiencies in our present knowledge was in the realm of biologic effects of air pollution. I urged that we increase as rapidly as possible our understanding of the impact of air pollution upon man and his environment. Dubos, in his testimony before the Daddario Committee in 1966, explained why the physiologist (and the epidemiologist) has been so delayed in providing more direct and convincing answers to the questions regarding air pollution and disease. He attributes the failure to the fact that "biomedical scientists have become conditioned to regard as really valid only the type of information they can derive from orthodox laboratory techniques.... Admittedly, the effects of environmental pollutants are not very impressive in this light. . . . The dangers to health posed by the usual levels of environmental pollution, and of air pollution in particular, are not readily detected because they are always delayed and often extremely indirect in their mechanism" (*4*).

Fortunately, in spite of the difficulties of investigation, there have been advances, both in laboratory and field exploration. Goldsmith has assembled extensive epidemiologic data on community exposures to concentrations of many ingredients or compounds in the atmosphere (including carbon monoxide, sulfur dioxide, smoke) (*5*). His contribution has additional value in delineating alternative strategies which may result from the findings of environmental epidemiology. Mark Perlman (*6*) has recently reviewed Max von Pettenkofer's lectures in Munich in 1873 on the effects of fresh air, spaciousness, temperature, and "the spirit of charity" upon death rates. Almost a century later, we must again consider these factors and their impact on urban living.

The cigarette-lung cancer syndrome has accelerated studies of diseases caused by air pollution. Many of these have been carried out in England, which has been plagued for years by a rising incidence of bronchitis and emphysema. Epidemiologic studies are attempting to determine the relation of these diseases and lung cancer to smoke, sulphur dioxide concentration, population density, and social index.

Geoffrey Dean has reviewed many of these findings, particularly in Northern Ireland, and says (*7*):

> It is more difficult to conclude that the association between urbanization and lung cancer is causal in nature. . . . In the light of all the evidence (New Zealand, South Africa, Australia and the Channel Islands)—it seems reasonable to conclude that the association between urbanization and lung cancer does reflect, at least in part, a cause and effect relationship. . . . The association between urbanization and bronchitis is well established. . . . Nevertheless, the evidence against atmospheric pollution is far from conclusive. If the association of urbanization with lung cancer and bronchitis mortality are both due to air pollution, then the forms or constituents of air pollution that contribute to bronchitis may not be the same as those that contribute to lung cancer.

Dean goes on to say that "reasons of cost ought not to be allowed to stand in the way of eliminating air pollution." In spite of this reasonable stricture, the editors of the British Royal Society of Health Journal assume a more conservative view (*8*): "Surveys of this kind always pose more questions than they answer, and one great difficulty is to obtain any real measure of the exposure of population groups to air pollutants." Nevertheless, there certainly seems to be an unidentified urban factor which has an impact on man. It is not yet clear whether this is the "geometry" of living, the house itself, the air, the special meteorology of a given region (inversion, temperature) or some of each.

The estimated cost of the destruction to plant life can be more accurately determined. Therefore, the U.S. Department of Agriculture has undertaken research to develop genetic resistance in plants, such as tobacco, or to control objectionable emissions at their source.

Administrative Criteria

The purpose of most federal, state, or local legislation is "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population" (S. 780, 90th Congress, 1st Session, 1967). Such a declaration is then elaborated in various official and semi-official documents, ordinances, rules, and regulations. The Engineers Joint Council defines air pollution in similar fashion, with the added caution that the air pollution should not "unreasonably interfere with the comfortable enjoyment of life and property." The recent report of the Panel on Electrically Powered Vehicles adds its recommendation: "The

national goal for air quality should be the achievement of an atmosphere with no significant detectable adverse effect from air pollution on health, welfare and the quality of life" (*9*).

These declarations leave the regulatory administrative officer somewhat suspended in midair. He can first develop appropriate standard methods of measurement of many constituents in air, and second, establish the criteria quantitatively which would accomplish the objectives of maximum advantage to society. However, both courses are difficult, because of the incomplete methods of measurement or appropriate criteria.

In the meantime, the administrator is confronted with a backlog of deficiencies which he must correct either with criteria on emissions or on fuels, or both. Some establish criteria described as "the most stringent in the United States." Others seek emission requirements of zero, on the hopeful assumption that something desirable will result. Already, resistances, demands for deferment of date of enforcement, threats of court action, and prophecies of economic collapse of some important industries, mark the American scene. It is not surprising that both the public and the elected official are impatient to clean the air. They expect the administrator to accomplish his objective rapidly.

In general, an enforcement officer prefers criteria which are blanket in nature. He seeks what the economist describes as "equiproportional abatement," if for no other reason than that it can be defended as avoiding preferential handling. "Selective abatement" is more time-consuming and perhaps even more costly in administration (*10*). In addition, the view recently expressed by one regulatory officer may be shared by many others; namely, that "he is not concerned with what it costs!"

Aside from the fragmentation of enforcement policies the causes of air pollution are of unequal significance according to source, location, and ease and cost of correction. If corrective policies are to bring the greatest return, areas must be carefully chosen.

In general, the motor vehicle accounts for some 60 percent of the air pollution in the U.S. The power plants contribute about 14 percent, and industry about 17 percent. Space heating and refuse disposal account for only 9 percent. As one views the regulations for the country as a whole, exclusive of California, much of the corrective action has been taken against the power plants. Is this because they are more visible, are fewer in number, or easy targets of public attack?

Regardless of the reasons, this group of pollution generators illustrates the problem of whether controls should be applied to fuel, to emissions at stack height, or at ground levels, or to all three. The criteria for the regulation of each of these in various parts of the country are not distinguished by any general principle or rationale. The rules most often reflect individual opinions, regulatory agencies, or public indignation.

The relative merits of criteria regulating automotive exhaust can now be assessed from experience gained in California. This experience should disclose whether emission standards, to be met by attached devices, improvements in the internal combustion engine, or by fuel changes, are the most promising of regulatory routes. Incidentally, the California experience, and its national application, raises some interesting questions as to why the automobile industry did not, of its own accord, develop more efficient combustion engines with less emission of objectionable pollutants. Similarly, the removal of sulfur from fuels by economical processes would certainly appear to be an obligation of industry. Is the obligation to be exercised only under legislative duress?

How much industry has participated in the formulation of legislative pollution control criteria is not clear. It appears that industry expresses its concern only after the criteria are announced. At that stage, to the bewilderment of the public, a dispute develops over the technical difficulties of conforming to the regulations. In testimony before Congress in 1966, Hibbard, of the Bureau of Mines, suggested that the devices then required for auto exhaust control would not be permanently useful or successful, but would simply afford time to develop more effective solutions (*11*). His suggestion was particularly disturbing inasmuch as federal standards were already considered as essential.

This discussion merely points up the lack of integrated decision-making by official federal, state, and local agencies. Even more important, in the formulation of criteria, is the absence of government and industry dialogues which, in theory at least, should result in practical and useful criteria (*12*).

Economic Impacts

In the preface to a recent symposium, *Economics of Air Pollution*, Gardner Ackley (*13*) points out that:

> Air pollution . . . is an important example of a problem in which the goals of public policy are mainly noneconomic, but have important economic aspects. Federal, State and local governments now have major programs to prevent and abate the pollution of the atmosphere. Yet many economic issues related to these programs are inadequately understood or documented. What are the benefits from cleaner air in improved health, reduced property damage, and increased aesthetic satisfaction? How much are these benefits worth? What are the costs of various methods and degrees of pollution abatement?

Contributors to this symposium discussed the difficult problems of benefit-cost analysis, of priorities, of decision-making, and of selection of alternatives within and in place of air pollution controls. All require thoughtful scrutiny by the administrators. It is equally evident that little or no attention is being paid to economic implications of the regulatory measures until they are protested. The greater part of the testimony before congressional committees omits discussion of the impact of public policy on the costs, benefits, and economics of the regulations.

Although the U.S. Public Health Service sponsored the symposium, it remains to be seen whether the general principles examined there will find their way into federal decision-making and, in turn, will affect the deliberations of state and local agencies. One deterrent to prompt action is the suspicion with which government officials regard economic analyses.

Time for Appraisal

In the last 10 years, Congress has recognized the significance of air pollution and has passed comprehensive legislation. The public has pressed for such regulatory and research measures. Professional groups have accepted the growing challenges in this environmental field (*14–16*). Administrators have proceeded to carry out federal laws.

In this effort to improve the quality of the air, a number of stumbling blocks arise. They include the difficulty of identifying relative causes and origins of pollution, of measuring the effects on man, plant, animal life, and property, of evaluating and setting reasonable limits

on discharged constituents, of assessing technological means of correction, of determining costs and benefits, and of understanding economic impacts. If we add the issues inherent in agency coordination and in fitting air pollution abatement into the ecology of the total environment, it is not surprising that there are unresolved problems.

Even this cursory review suggests the obvious difficulties a crash program of correction inevitably presents. For this reason recurring appraisals of our situation would seem wise, at intervals of every 5 years. An authoritative group should undertake such a task. A precedent is already available in the comprehensive contribution of 1965 made by the Air Conservation Commission of the AAAS (*17*). Much has been done since that report of 3 years ago. A recurring assessment would be helpful in evaluating results, in disclosing areas of ignorance, in developing new concepts, and, above all, in leading to improved coordination and integration of the many strategies now being pursued.

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NEWS AND COMMENT

California: Reagan, Draft Put Gloom on University's 100th Year

California. This is the centennial year of the University of California, and, by the usual measures of academic girth and quality, there is much to celebrate. U.C., with nine campuses up and down the state, breaks or presses all records for enrollments, expenditures, Nobel prizes, membership in the National Academy of Sciences, Guggenheim awards, Woodrow Wilson fellowships, and numerous other marks of scholarly scope and achievement. Though money is said to be unprecedentedly tight, great construction projects are under way on virtually every campus to accommodate an ever-growing student body. And, as symbolized by the move last year of Nobel laureate Charles Townes from M.I.T. to U.C., California still draws the stars.

Nevertheless, against this background of achievement, and, in fact, because of it, the people responsible for the affairs of U.C. today comprise what is probably the gloomiest set of administrators in all of higher education. And their mood is not without cause, for relations between Governor Ronald Reagan and the university have now settled down to a condition of subdued hostility that is steadily eroding the margin of money, elan, and confidence that made U.C. the greatest system of public higher education in the nation.

It has to be emphasized that, at its best, U.C. still stacks up well against any big university in the country. But a visitor who has been away from California for 18 months finds that, after 4 years of large and small crises at Berkeley, 2 years of unsympathetic scrutiny and budget chopping by the Governor, and, in many quarters, a never-ending anguish over the Vietnam war, vigor and stretch seem to have gone out of the statewide system. Atop all this, there are the new draft regulations, which, to an astonishing degree, have brought the war home to many faculty members and administrators who previously managed to remain more or less aloof from war-related concerns.

All but a few persons will applaud the fact that Berkeley, renowned for the volatility of its campus politics, has for some time now been relatively quiet. But this quiet, it seems, is more a result of weariness and the activists' concentration on noncampus issues, such as the war and now the draft, than of any resolution of matters that once aroused the strongest responses. Administrators who once exuded confidence about the long run welcome the placidity on campus, but, looking outward to the state government that supports their institution, they now readily admit to doubts and discouragement about the future. Thus, Berkeley chancellor Roger W. Heyns remarked in an interview with *Science*, "There has never been more statewide hostility to the University than there is now, and it shows up in the way they treat us in Sacramento." A graduate dean on one of the university's major campuses, a normally ebullient fellow who has ridden out many storms, frankly states, "I have a feeling of absolute futility. There's a general fatigue here. People are really afraid of Reagan. He's shown that he can hurt us, and that there's nothing much we can do about it. And the depth of feeling against the draft is really difficult to believe. People in large numbers are seriously saying they will leave the country or go to jail rather than be drafted." And the widely admired chancellor of one of U.C.'s fast-growing campuses remarks, "There's a sense of insecurity such as I've never seen before. There's an absence of trust that makes it very difficult for an institution to function. A lot of people simply don't trust anyone anymore. I'm not used to having people look me in the eye and say, 'I don't believe you.' "

To some extent, these administrators are merely reflecting the anxieties and frustrations that beset most man-