

*The Environment and Agriculture*

A RACE FOR SURVIVAL

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Man is changing the world environment. He has been doing this almost from the time of his appearance as a new species a million or so years ago, but now he has become so numerous and technologically adept that there is a real danger he may destroy the ability of the earth to support life.

Early man subsisted by gathering wild foods and by hunting and fishing. At some point he discovered that he could use fire to drive game animals, and this was the start of man-made air pollution and soil erosion. However, early man was incredibly lucky. In many places the forests he burned were replaced by grasslands which supported increasing populations of grazing mammals, and these grasslands developed soils that would eventually place them among the world's most valuable lands for agriculture. Although the evidence is lost in the past, man's first use of grasslands was probably for the grazing of domestic animals, and this grazing probably helped to inhibit the regeneration of forests.

Early agricultural man would have found it virtually impossible to cope with the heavy sod of grasslands, and so he confined his efforts to the flood plains of rivers where the soil was fertile, well watered and easy to cultivate with simple tools. He learned to store food so that the produce of the growing season could support him and his domestic animals throughout the year. Then he started to build towns and cities and to expand his numbers, and he felt the need for more agricultural land and year-round agriculture. These needs were satisfied by building dams and canals for irrigation. Great civilizations grew up in the valleys of rivers such as the Tigris, Euphrates, Nile and Indus, and their human populations multiplied.

**The Ravaging of Resources**

There were, however, side effects. The very crowding of people into towns and cities exposed them to frequent epidemics, and these, together with wars and famines, took a frightful toll of human life. The smoke from man-made fires polluted the atmosphere, and the erosion of soil from burned-over and over-grazed slopes polluted bodies of water and sometimes blocked streams to create swamps and marshes with attendant health hazards such as malaria. At this stage man could not anticipate the disasters that his own activities were bound to create. Without adequate drainage, for instance, his irrigation works would cause water to move upward through the soil, where it would evaporate and deposit a fertility-destroying layer of salts on the surface.

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As soils were rendered lifeless by salts and as irrigation systems filled with silt, great civilizations vanished. Pliny tells of the farmers of the great Babylonian Empire, dating from before 2000 B.C., who harvested two annual crops of grain and grazed sheep on the land between crops. Today less than 20 percent of modern Iraq is farmed. The landscape is dotted with mounds representing forgotten towns, the old irrigation works are filled with silt (the end product of soil erosion), and the ancient seaport of Ur is now 150 miles from the sea with its buildings buried under silt as deep as 35 feet.

We hear a great deal today about the 'underdeveloped' and 'developing' nations but, as in the case of Iraq, many of them could more accurately be described as *overdeveloped* nations. Modern Iran was once the seat of the great Persian Empire where Darius I was the 'King of Kings' 2400 years ago. Ancient Greece had forested hills, ample water and productive soils, and it is clear from Plato's *Critias* that he knew that deforestation and overgrazing could cause soil erosion and the drying up of springs. Apparently nobody listened to his warnings.

The glories of ancient Mali and Ghana in West Africa were legends in medieval Europe. In the land that once exported the cedars of Lebanon to Egypt, the erosion-proof Roman roads and the soil beneath them now stand several feet above the rock desert. In China and India, ancient irrigation systems stand abandoned and filled with silt. India, two centuries ago, had a population of about 60 million. Today it is over 500 million and most of its land problems have been created in the past century through deforestation and plowing and the resulting erosion and siltation, all stemming from efforts to support such fantastic population growth.

Everyone knows about the wonders of ancient Egypt. The annual spring flood of the Nile watered and fertilized the soil, and crops could be grown for seven months each year. Extensive irrigation systems were established before 2000 B.C. The country was the granary of the Roman Empire, and agriculture flourished for nearly 4000 years. But in 1902 a small dam was built at Aswan to prevent the spring flood and permit year-round irrigation. Now the soils are deteriorating from salinization. The new Aswan high dam is designed to bring another million acres of land under cultivation; but the resultant deterioration of the soil may prove disastrous. Meanwhile, population growth has virtually destroyed any possibility that the new agricultural land can significantly raise the per capita level of nutrition.

### **Erosion in the Americas**

In various parts of Central and South America, modern aerial reconnaissance has revealed ancient ridged fields on flood plains. These are the remnants, according to J. J. Parsons and W. M. Denevan, of 'a specialized system of agriculture that physically reshaped large parts of the south American continent.' In many parts of Mexico towns that were originally located to take advantage of superior springs now must carry in water from distant sites. And in Guatemala and Yucatan the ruins of the Mayan civilization stand as stark evidence of what the land was once capable of supporting.

In the comparatively young United States, thousands of acres of agricultural land have been lost to erosion and gulying, and thousands more to strip mining. The inherent fertility of the best agricultural land is declining so that yields can only be maintained or increased by massive programs of fertilization. In the irrigated lands of the western United States there is the constant danger of salinization, while from Long Island to southern California we have lowered water tables so greatly that in coastal regions salt water is seeping into the aquifers (water-bearing beds of earth, gravel or porous stone). Meanwhile, an estimated 2000 irrigation dams in the United States are now useless impoundments of silt, sand, and gravel, and a conservatively estimated million acres of land per year are being sacrificed to paving, building, and other manifestations of "progress."

This is what man has done to the land. In the last 300 years, more-over, he has been able to accelerate his destructive processes by obtaining energy from the fossil fuels—coal, peat, natural gas, and petroleum. Several recent surveys have found that modern "progressive" farmers expend more calories running their machinery that they remove from the land in crops. Now, quite suddenly, man has come to realize that these fuels will soon be exhausted — various estimates of the time-table give us anywhere from 20 years to a half-dozen generations. By then, present thinking holds, we shall have converted to nuclear energy. But uranium and thorium are also exhaustible resources, and modern reactors convert less than one percent of the energy in their fuel into electricity — as compared with some 40 percent for conventional plants burning fossil fuels. Indeed, the nuclear age threatens us with a wholly new magnitude of global contamination.

### The Growth of Pollution

Like soil erosion and deforestation, man-made pollution has an ancient history. Neolithic man started pollution of the environment with his fires, though the major resulting pollutions — smoke, soot, silt — also existed without man. But many new pollutants appeared as civilization advanced. The Romans mined lead in Britain and smelted it there, and it is said that the sites of these old smelting operations can still be recognized by the impoverished vegetation growing on the poisoned soil. In Rome the lead went into paints, water pipes, and the lining of vessels in which wine was stored. Recent studies of Roman bones have shown concentrations of lead which indicate that many members of the upper classes must have suffered from lead poisoning ; it has even been suggested that this may have contributed to the decline of the Empire.

As cities grew they began to concentrate materials produced over a wide area into a small space, and as these materials gave rise to wastes, pollution problems arose. Otto of Freising's *Chronicon* tells us that when Frederick Barbarossa's army arrived in Rome in the summer of 1167 ; '...the ponds, caverns, and ruinous places around the city were exhaling poisonous vapors, and the air in the entire vicinity had become densely laden with pestilence and death.' Waters were also polluted. The name 'Rhine' was supposedly derived from the German word for 'pure,' but by the 13th century St. Hildegard wrote that the Rhine's waters, if drunk unboiled, would 'produce noxious blue fluids in the body.'

Man added a whole new dimension to environmental pollution when he started burning fossil fuels for energy. In the year 1306 a citizen of London was tried and executed for burning coal in the city, but three centuries later coal combustion was a way of life and London had a smog problem. This new source of energy made it possible for many more people simultaneously to inhabit the earth than ever before, and the resulting colonization and exploitation of new lands further aggravated environmental deterioration.

With the start of the 20th century, petroleum assumed a growing role as a source of energy. The internal combustion engine and a huge, diverse chemical industry have released into the environment countless new materials to which the world's living things have never before had to adapt. Miraculously, man's run of blind luck has continued — and the biogeochemical cycles on which his life depends have kept on functioning. But in the last three decades man-made stresses on the environment have so intensified that it would be incredible if such luck long continued.

The pollution problem, of course, is not limited to the by-products of our commercial activities. Waste matter is also a major culprit. We have continued to dispose of our wastes as of old — largely by dumping them into the atmosphere and hydrosphere — and human populations are now so dense that it is difficult to see how we can ever reclaim a clean environment.

Because of these biological wastes and other pollutants, it has been estimated by the U.S. Food and Drug Administration that we are now exposing ourselves and our environment to over a half-million man-made substances, and that this number is growing by between 400 and 500 new chemicals per year. Just in the past 24 years we have asked the environment to cope with such unprecedented classes of materials as synthetic pesticides, plastics, antibiotics, radioisotopes and detergents.

### **The Oxygen Balance**

The end of our production of novel chemicals is not in sight. No more than a minute fraction of these substances, singly or in combination, has been tested for toxicity to the marine diatoms that produce some 70 percent of the earth's annual supply of oxygen. Nor have they been tested for toxicity to the equally vital forms involved in the cycles of nitrogen and other essential elements.

For the continental United States I have attempted some calculations of the oxygen balance. I took the figures for production and imports of fossil fuels for the year 1966, corrected these for exports and non-combustible residence, and calculated the amount of oxygen that would be required for their combustion. Then I made what I believe to be a good estimate of the amount of oxygen produced by photosynthesis within U.S. borders that year. The amount of oxygen produced turned out to be not quite 60 percent of the amount consumed.

The implication is clear ; we are absolutely dependent on oxygen which is produced outside U.S. borders — mostly in the Pacific Ocean and brought in by atmospheric circulation. If we should inadvertently kill enough marine diatoms or the organisms they depend on for fixed nitrogen, we would start running out of oxygen to breathe. Yet these organisms are now being exposed to our half-million chemicals. There is some evidence that the insecticide DDT can suppress photosynthesis in bodies of water, and this chemical has now become world-wide in distribution. More frightening yet are the herbicides or "weed killers" — chemicals specifically designed to be poisonous to plants. The fate of Lake Erie and many lesser bodies of water has shown that man is capable of blocking the oxygen cycle through sheer carelessness.

### **Our Contaminated Air**

Most textbooks describe the atmosphere as it would exist if it were free of contaminants. In our actual atmosphere, however, more than 3,000 foreign chemicals have been identified. The air of our cities is rich in solid matter such as soot, fly ash, particles of rubber from tires and asbestos from brake linings — all of which have implications for public health. Our smoke stacks and exhaust pipes pour forth carbon monoxide, sulphur dioxide and various oxides of nitrogen ; these chemicals can affect health and, in the case of the sulphur and nitrogen oxides, they are capable of corroding metal and concrete.



*The oceans are the ultimate repository of our half a million chemicals. If we kill the marine flora, we shall have no oxygen to breathe.*

In addition, ethyl gasoline causes our automobiles to release so much lead to the atmosphere that snow near the North Pole contains 300 percent more lead than it did in 1940. And, to increase agricultural output, we have processed phosphate rock into fertilizer, releasing as a by-product poisonous fluorine which ironically sometimes kills vegetation and livestock in the vicinity of the fertilizer plants. Ironically also, our laundry detergents are compounds of phosphorus, and we are discarding this precious element so recklessly that it has become one of our most significant water pollutants.

What about our over-increasing use of fossil fuels? We are burning them at a rate which is putting carbon dioxide into the atmosphere more rapidly than the oceans can assimilate it. Carbon dioxide is quite transparent to solar radiation but quite opaque to the longwave heat radiation from earth to space. In other words it creates a heat trap which has the potential for altering the earth's climates. The precise form that such changes might take are still very controversial and uncertain.

People are grasping at straws for ways to keep our economy growing. We are told that bacteria, fungi and yeasts will convert fossil fuels directly into food for man. Not only are fossil fuels exhaustible, but, unfortunately, this proposed new type of food production will not generate any oxygen.

### **The Problem of Radioactivity**

We are told that nuclear energy will provide the answer to air pollution. This may be the cruelest hoax of all. Before the controlled release of atomic energy, the amount of radioactivity under human control consisted of about 10 curies, in the form of about 10 grams of radium divided among the world's hospitals and laboratories. Great concern and publicity arose whenever a few millicuries were lost or misplaced. Those who can recall this concern will not take lightly the news that a nuclear power plant now being constructed on the shores of Lake Ontario near Oswego, New York, will by the company's own estimate, release 130 curies per day into the atmosphere. And this plant is actually to be a small one in terms of present dreams.

Present-day reactors produce prodigious quantities of extremely hazardous and long-lived radioisotopes such as Strontium 90 and Cesium 137 which, everyone agrees, should be stored for at least 600 years before being released into the environment. Yet the Atomic Energy Commission found that about 5 percent of the underground storage tanks were leaking after only about 20 years.

In all of the foregoing instances of pollution the fundamental problem, as I see it, is our fetish for equating growth with progress. Economists state that companies must grow to survive. We take pride in a gross national product growing at between 4 and 5 percent per year, and we try to ignore the fact that our per capita production of trash is growing at about the same rate. We are told that our electrical generating capacity must increase by 10 percent per year, but we forget that all of that energy must eventually be imposed on the environment as heat; I don't believe that there is any way short of repealing the laws of thermodynamics to sustain such growth without bringing disaster to our environment.

### **Population and Pollution**

In a related field, growing populations are viewed by many planners simply as expanding markets—and here we come to a fundamental problem. There must be *some* level of human population that the earth could support indefinitely without undergoing deterioration, but we don't know what that level is. Through

the first million or so years of man's existence, his population probably doubled no more often than once in every 50,000 years. During the summer of 1968 the human population passed the 3.5 billion mark, and, if present trends should continue, this population would double again every 35 years ! There is no possibility that the earth's environment can long sustain such pressure ; in fact I consider it very improbable that the earth could continually support, on a nondestructive basis, a population as large as the *present* one. We shall have to decide, and soon, what quality of life we want for ourselves and our children, and what steps in pollution and population control are necessary to get it.

Unfortunately, our big decisions are made on economic grounds. Factories burning fossil fuels don't *have* to release particulates and sulphur and nitrogen oxides into the atmosphere ; nor do nuclear plants, barring accidents, *have* to release radioisotopes into the environment. They do these things because it would cost money not to. Pollution by automobiles could surely be controlled at some expense and perhaps with some loss of performance. There are valuable raw materials in discarded automobile bodies ; if economics made the mining of fresh ore as expensive as reclaiming used metals, our auto graveyards would vanish. Throw-away glass bottles are the thing today, and federal law even prohibits the re-use of liquor bottles — thereby adding to the burden of trash. Even metal cans could have salvage value, as they did for a while during the tin shortage of World War II. The organic matter in garbage and sewage could be converted to fertilizers, but not at present competitive costs. Other wastes could be burned in smokless incinerators and the heat could be made to do useful work, as is being done on a small scale in Europe.

#### Who Should Pay ?

Influencing all the foregoing choices we might make is the question : *Who should pay for pollution ?* Our system now allows the public utility, the manufacturer, the chemical company and the incinerating firm to dump pollutants into the air at little or no cost. Other people pay the bill : the city government which must repair its roads and bridges and replace its trees far too often, and the emphysema sufferer who must frequent a doctor's office. If the bills for pollution were handed back to the sources of pollution, we might see some surprising improvements in the quality of our air. But such a system of social accounting, I hasten to point out, involves political and ethical decisions rather than purely technological ones.

Meanwhile, we are on a collision course with disaster. It is encouraging to know that we already have, or can develop, the technology to reverse our course. But it is disturbing to realize that we have not yet applied this technology in an effective way. We know how to regulate population size and how to do it economically. We could control pollution and even do a great deal to clean up our filthy and deteriorating environment — provided, of course, that we have not already made disaster inevitable by dooming some species on which the continuation of life depends or by burdening ourselves with a load of defective genes that will make future human generations unviable.

Surely, man faces no more urgent problem than the need to save his environment. What will be required is intense collaboration by the best minds among biologists, physical scientists, sociologists, economists, political scientists, and policy makers. In the United States, as well as elsewhere, many of these people are beginning to recognize and deal with the critical problems of survival. We can only hope that enough time is left for them to do their work.