Man, the Destroying Biotype

Man's persistent disruption of natural equilibria poses a constant threat to his means of subsistence.

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Freedom cannot thrive in lands oppressed by hunger and want.

The great technical achievements of our age, which are so wonderfully expressed in the United States, must not make us forget this fundamental truth: Man remains bound to the environment in which he lives.

In this article I want to present some facts and impressions gathered during my travels, especially in certain tropical regions. I want to develop the following points: (i) The place of man within the biosphere; (ii) the ecological significance of the exploitation of natural resources for purposes of human nutrition and industry; (iii) natural equilibra and the regression of soils; and (iv) the protection of the human habitat.

Man can live and find suitable food only under certain geographical conditions. The earth has a surface of about 500 million square kilometers; more than two-thirds of this is covered by the seas. Of the remaining 127 million square kilometers, glacial areas, high mountain peaks, and deserts are unfavorable for human habitation. Man is thus confined to less than one-eighth of the total surface of the globe. He is further limited by an extremely thin layer of breathable air and a thin layer of arable land in which plants can grow and on which animals and men can live. The elements of nature—light, air, water, soil, plants, animals, and men—are closely linked to one another; any perturbation of one releases a cascade of repercussions upon the others. In the course of thousands of years certain balances have been established. Sometimes they have been upset.

Man seems reluctant to accept his place in nature. He declares that the power of his genius, the vastness of his technical achievements, and the abundance of his populations places him beyond the limits of nature. He forgets that he is the outcome of a long series of evolutionary adjustments and that his ascendency over nature is recent indeed.

His first appearance dates back about a million years, it is true, but for ninety-nine hundredths of that million-year period he lived in small dispersed groups as a minute part of the jungle, striving against the elements, threatened both by the brutality of wild life and by the ravages of disease. It is only in the last hundredth of his time on earth that he has discovered the means of defending himself and has become able to increase his numbers and acquire greater knowledge. The oldest civilizations, whether Chinese, Indian, or Egyptian, go back less than 30,000 years and did not become of real importance before 7000 to 10,000 years ago. During that 10,000 years, through science and its techniques, man has improved his lot to a fairly marked degree.

His numbers are now extraordinary. The population of the globe, assessed at about 20 millions 5000 years before our era, had increased to 500 millions by the 17th century. The beginning of the industrial era at the end of the 18th century, with the introduction of steam and electricity, the mechanization of agriculture, and the discovery of fertilizers, brought about a staggering advance in production and also a staggering increase in the birth rate. By 1900 the world population had risen to 1.5 billions, and by 1952, to 2.6 billions. The population of the globe has increased fivefold in 300 years. Recent forecasts indicate that 40 years hence, in the year 2000, there will be 6 billion human mouths to feed. Russia today has a population of about 200 millions. In 1990 there will be 400 million Russians. England's demographic expansion came somewhat earlier; at the end of the 18th century there were just over 10 million inhabitants in Britain (Scotland included); today there are some 50 millions. In China each year brings an additional number equivalent to the population of England.

Man has very rapidly conquered and exploited the available natural resources for the needs of his economy. Nothing stops him in his ever more audacious achievements; he pierces mountains, builds dams, casts bridges across arms of the sea, turns rivers from their courses, gains mastery of the air; he hews down forests and vastly extends the areas of cultivation; he releases almost unthinkable nuclear forces. *Homo sapiens* has become *Homo economicus*.

Yet will he ever be able to escape from his nature as a living being, subject like other living beings to biological feeding requirements? Will he be able to escape the conditions of the environment in which vegetation is the only basic producer of the essential organic materials? We must remember that it is strictly from the plant and animal kingdoms that we get our sustenance. All flesh *is* grass; it is the organic matter synthesized by plants which constitutes the basis of our foodstuffs. We are dependent on the wonderful, complex little factory that each green leaf represents. Green plants alone have the power to synthesize from the carbon dioxide of the air and from water, at low temperature and by means of light, chlorophyll, the protoplasm of plant cells, and the sugars that mark the transition from inorganic to organic matter. If land and sea plants ceased to fulfill this function there would be no more sugar nor meat nor oil nor cotton nor flax nor rubber nor paper. All life would come to an end on the surface of the earth. The delay would be one of but a few months, despite the large stocks of certain foodstuffs that are accumulated in some places.

The biological limits of plant synthesis as well as the ecological balance in the medium thus determine the world potential of life. These two factors place limits on man's food supply and on the reserves of energy needed by his industries. Whether he likes it or not, the problem of resources of energy (petroleum, coal, wood) from fossil deposits and the problem of feeding humanity are closely linked to the prob-

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Four stages in the "reclamation" of a tropical forest. (Top left) Virgin rain forest; (top right) clearing, carried out by cutting and burning; (bottom left) cotton growing among the stumps of the former forest; (bottom right) the next-to-final stage—the cultivated fields have been abandoned, but erosion is just beginning.

lem of balance between various elements of the biosphere of which man is inevitably a part. Nuclear energy has opened up new horizons in the sphere of industry, but *not* in the realm of foodstuffs. Before man tries to explore the moon he must continue to eat on earth.

In regions of temporary abundance, such as America and some parts of Europe, the question of food does not force itself on public attention. We think of it only when we must draw up a medical diet or analyze a cooking recipe or solve pressing problems of markets, of transportation, or of purchasing power. When we look beyond the bounds of these regions of abundance, however, one fact cannot be escaped: there is not enough food for the present number of living beings. One-third of the world's population has enough to eat. This third alone eats three-quarters of the crops harvested over the entire earth. The other two-thirds of the human race have not enough to eat, and this situation is getting worse each day, as 120,000 new beings a day are born. The globe is at present able to feed only 4 billion inhabitants on a ration of 2800 calories per person per day (in America the daily individual consumption is about 4000 calories; in Sweden, 5000). In the year 2000 there will be 6 billion mouths to fed, on a planet where there is less and less useful land.

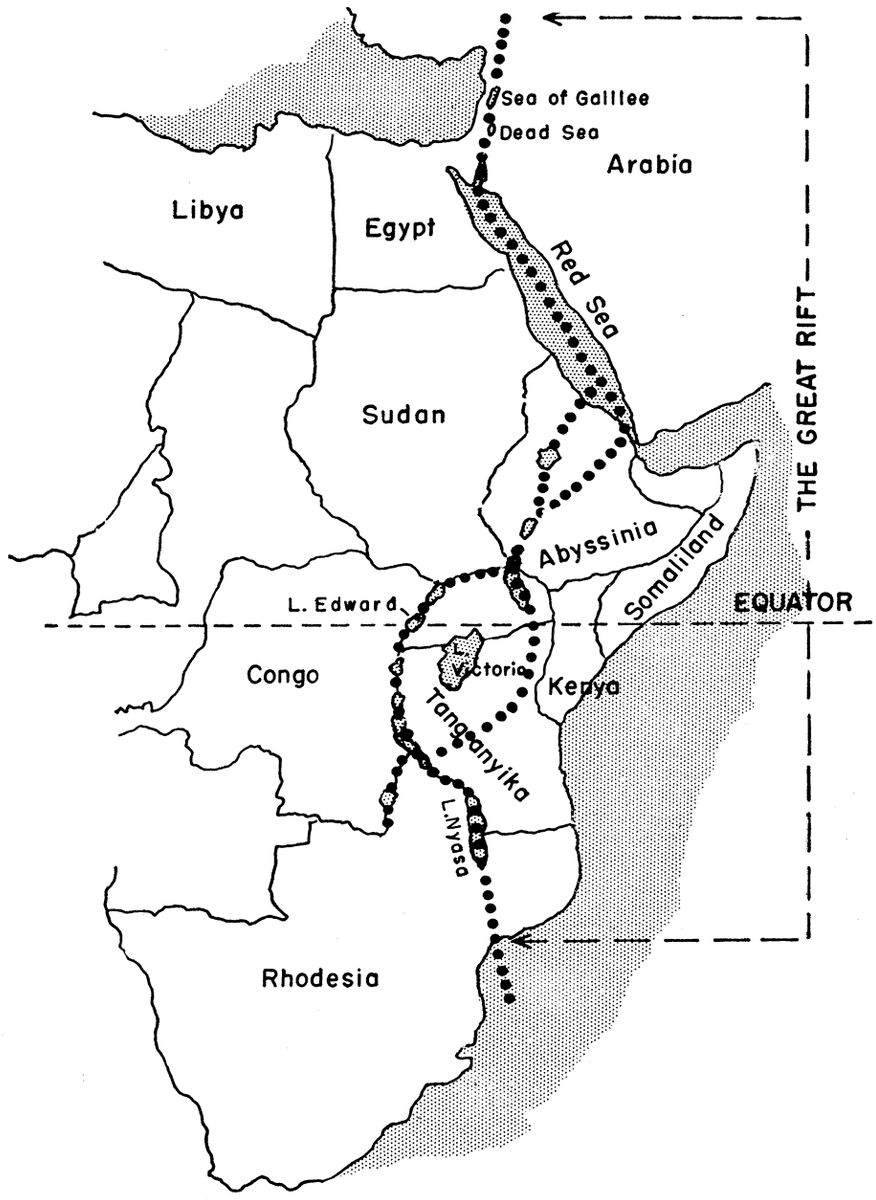
The surface of cultivated lands cannot be extended indefinitely. To solve the problem some advocate the opening and development of new lands, others urge the application of the results of laboratory research through which such progress has already been made in the fields of plant physiology, selection, agronomy, and phytopharmacy. It is possible and indeed probable that some gains may be made through the use of fertilizers, the judicious application of the laws of plant growth, knowledge of soil conditions and suitable climates, and application of new cultivation techniques. But—though this solution may seem the most obvious and rapid—we must beware of the strictly temporary gains that would come from clearing forest regions which have kept their primitive character. Reliance on such solutions could be disastrous.

The expansion of human populations and the extraordinary increase in the technical means at their command are creating a serious state of disequilibrium. The speed with which detrimental changes have occurred in recent centuries is fantastic. Cultivation has already so extensively replaced natural conditions, over numerous and vast territories, that very little of virgin nature remains. And reduction of forest areas below a certain limit has been proved to have serious consequences. It disturbs a whole series of natural balances, causing floods, drought, erosion, lowering of the water table, depletion of

soils, dust storms, changes of climate, and so on.

In most parts of the world the progressive clearing of forests to acquire virgin humus has been practically unbridled. Only in Europe, where agriculture has been established for a long time and where the consequences of certain states of imbalance have been gradually recognized, is this not true. Elsewhere, cultivation is abandoned when the soil becomes unproductive. Then herbaceous plants appear and are generally used as pasture. Because of the need for pastureland, grassland has been burnt off so that it will not become wooded. Where this is done, a great number of useful plants disappear, to be replaced by a small number of pyrophilous varieties that are often not suitable even for pasture. The vegetative cover disintegrates, especially when, as often happens, there is overgrazing. The soil, laid bare, undergoes extensive changes in structure and composition. It loses its colloids, becomes dust, hardens into laterite, or is carried away by erosion.

Thus we witness, in what was formerly a slow but is nowadays a rapid regressive chain, the degradation of plant groups, on disorganized soils made barren, in areas veering toward aridity. The influence of these climates has an untoward effect on the adjacent forests and zones of cultivation.



East Africa, showing the location of the "Great Rift" and the general mountain massif. The Albert National Park lies at the point where the Great Rift is intersected by the equator.

The delicacy of the balances in the great tropical forests, the luxuriance and wealth of which seem to suggest great stability, is particularly evident to me, as biogeographer and ecologist. This stability does not exist. The great forests of the hot regions are *less* resistant than are the forests of our temperate climate. The equatorial soil is generally poor; the forests can live and subsist in these regions only because they are part of a closed and hence balanced cycle. The organic matter that falls from the trees constitutes the humus; all that the forest produces returns to the forest. If the forest is interfered with, if the soil is laid bare, the humus decomposes very rapidly, and in hot, damp regions it is not renewed. It is reduced to soluble mineral salts, which the rains easily and swiftly wash away.

The losses of nitrates and ammonium salts are highly subject to variations in temperature; the rise of a single degree in the atmospheric temperature, between 25° and 26°C, for example, may increase the nitrogen loss by 15 to 20 pounds per acre per year. And the destruction of the forest exposes the soil to conditions that produce a considerable rise in temperature.

The beautiful forest region of the Lubilash, in the Congo, is established on sand covered with a thin layer of humus. Clearing such a forest for agricultural purposes brings about a rapid exposure of the sterile subsoil. The soil becomes unproductive after 3 or 4 years and has to be abandoned. Furthermore, industrial crops such as cotton and *Pyrethrum* do not completely cover the cleared soil, which thus suffers severe depletion the year round as a result of exposure to the hot sun, desiccation, washing away by rain, and erosion. And finally, before undertaking cultivation, it has been necessary to clear away the trees cut down, by burning them. Fire destroys not only the superficial organic bed that has accumulated but also all the microflora of the soil, a large part of which consists of mycorrhizal fungi in symbiosis with the roots of the trees themselves. The microflora of a healthy soil 30 centimeters thick may represent a mass of 5 tons per acre. After the fire the micorrhizal organisms are replaced by a commonplace microflora unsuitable for recon-

Mount Visoke (altitude, 11,500 feet). Lake Kivu, in this region, is at an altitude of about 5000 feet. The small lake in the picture lies at about 8000 feet.

structing the forest after the cultivated fields have been abandoned. Here, certainly, we may say that between mankind and starvation there are but 20 to 30 centimeters of soil. This precious part of the earth is a mixture of the products of superficial disintegration of the rocks and of humus resulting from the decomposition of living things, particularly of plants which have lived on the surface over past ages. It is my judgment that, under natural conditions in this area, 2 to 3 centimeters of such a humus takes 1000 years to form.

One may, from an aeroplane during long transcontinental flights, observe with dramatic force this decadence of the plant kingdom over the surface of the globe. An experienced observer is amazed to see so many areas without forests, so many desert steppes and brushwood areas at every stage of denudation. This situation is generally the outcome of land clearance, cultivation, conversion to pasture, and fire, by the hand of man. The conditions required for cultivation of plants are completely wiped out. Man's means of feeding himself have become progressively more and more precarious. It is therefore not surprising that archeologists are discovering, precisely in those zones where semiarid or desert conditions prevail today, the remains of dense and prosperous ancient populations. The present-day causes, which we can see quite clearly, must have acted in the past as well, though perhaps more slowly. We do not need to ask ourselves why these civilizations disappeared, why the fields these peoples used to cultivate were abandoned.

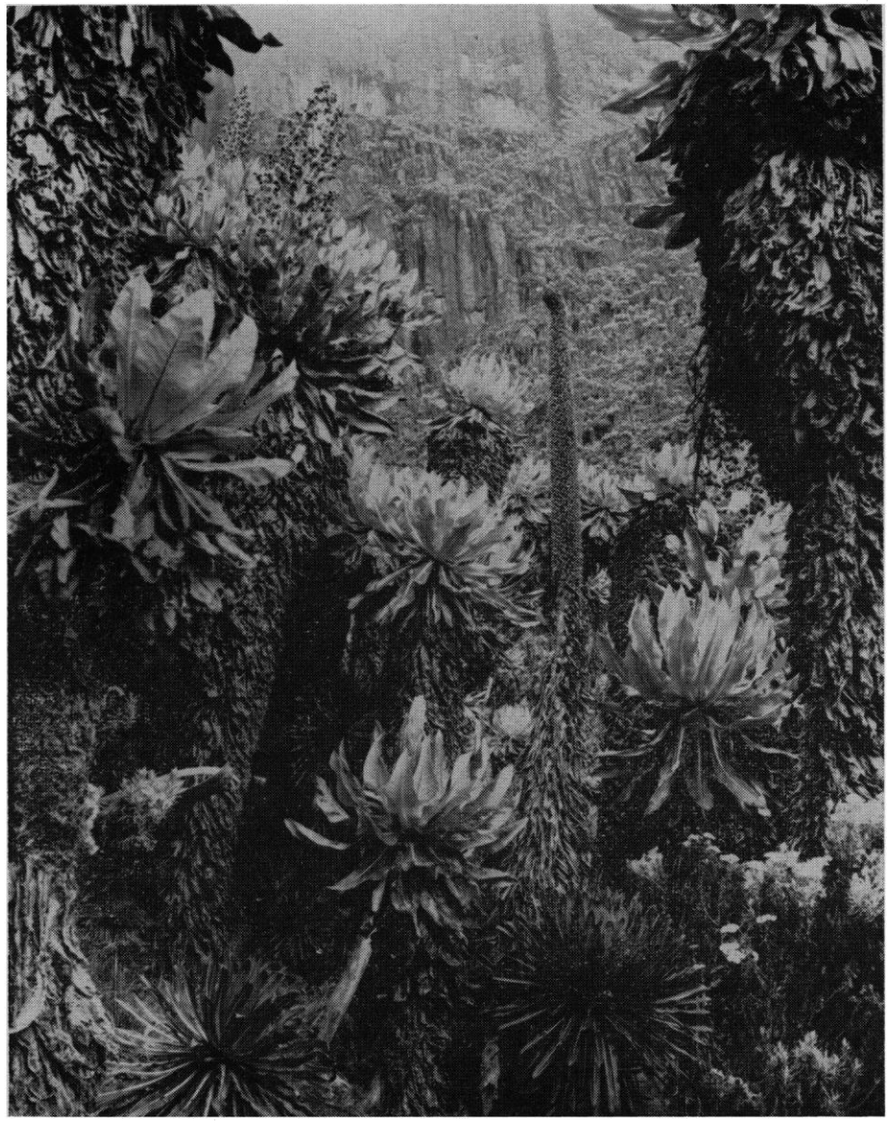
Egypt, which now occupies only the Nile Valley, like China, which clings to the valleys of the Blue River and the Yellow River, formerly covered the now desert spaces with its fields. Cyrenaica, at the time of imperial Rome, possessed the famous Gardens of Berenice. The Libyan Desert hides the ruins of great towns such as Thysdrus (El Djem), whose stadium was built to hold 60,000. The French explorer August Chevalier discovered in the Sahara, beneath thick layers of sand, traces of dense forests which, less than 2000 years ago, made a rich colony of what is now synonymous with barrenness and aridity. And the list does not end here; Arabia, Babylon, and Tibet can be added. In Morocco, since the Roman period, 12½ million acres of forests have disappeared as a result of fire and overgrazing by sheep and goats.

In the great forest massif of Central Africa, where the rate of regression is rapid, the present state of affairs is becoming disastrous, owing to the activity of the natives, who still start fires to clear the land for hunting and cultivation. This forest area, which is bounded on the north by the Sahara and on the south by the semiarid regions of the Kalahari, is receding with alarming speed. On all sides the deserts are advancing. It is estimated that in French Equatorial Africa alone the loss of fertilizing matter during the present generation has amounted to half a billion tons, and in a single cotton district in the Congo agronomists have shown that in 6 years 30,000 square kilometers of soil have been ruined. In Madagascar the drama has been played out over a period of 60 years. This island was once covered with splendid forests; today 70 percent of its area is occupied by an ocean of tough grasses, ravaged by fire and unsuitable even for the feeding of herds. In short, we are in the throes of an apparently irreversible progressive *reduction* of the surface of cultivable lands. It is estimated that the

area of such lands on the earth has decreased by 20 percent in the last hundred years. Of the 40 billion acres remaining today, at least 20 million disappear irretrievably each year.

The lesson of the past is clear: We *cannot* continue to exploit nature with impunity. We cannot clear away the forests and enlarge the areas of cultivation without bringing about disturbances in the equilibrium which, throughout the globe, result in disappearance of areas of vegetation, impoverishment of the fauna, erosion, disappearance of the water table, depletion of nutritive elements (particularly of nitrogen carried off by the crops and not restored), degeneration of lands to desert wastes, famine, decline of civilizations, migration of populations, revolutions, and wars of extermination.

Today, therefore, we can measure the extent of the threat which hangs over our descendants and the urgency of the problem which it is absolutely necessary that we solve. We must end the degradation of vegetation and the erosion of the earth, everywhere on the surface of the globe. This problem cannot be left to any nation of indifferent or inactive individuals. In some countries, departments with extensive powers are studying and applying the means advocated for preventing complete sterilization of the land. The International Union for the Protection of Nature has undertaken a propaganda campaign. We wish it every success.



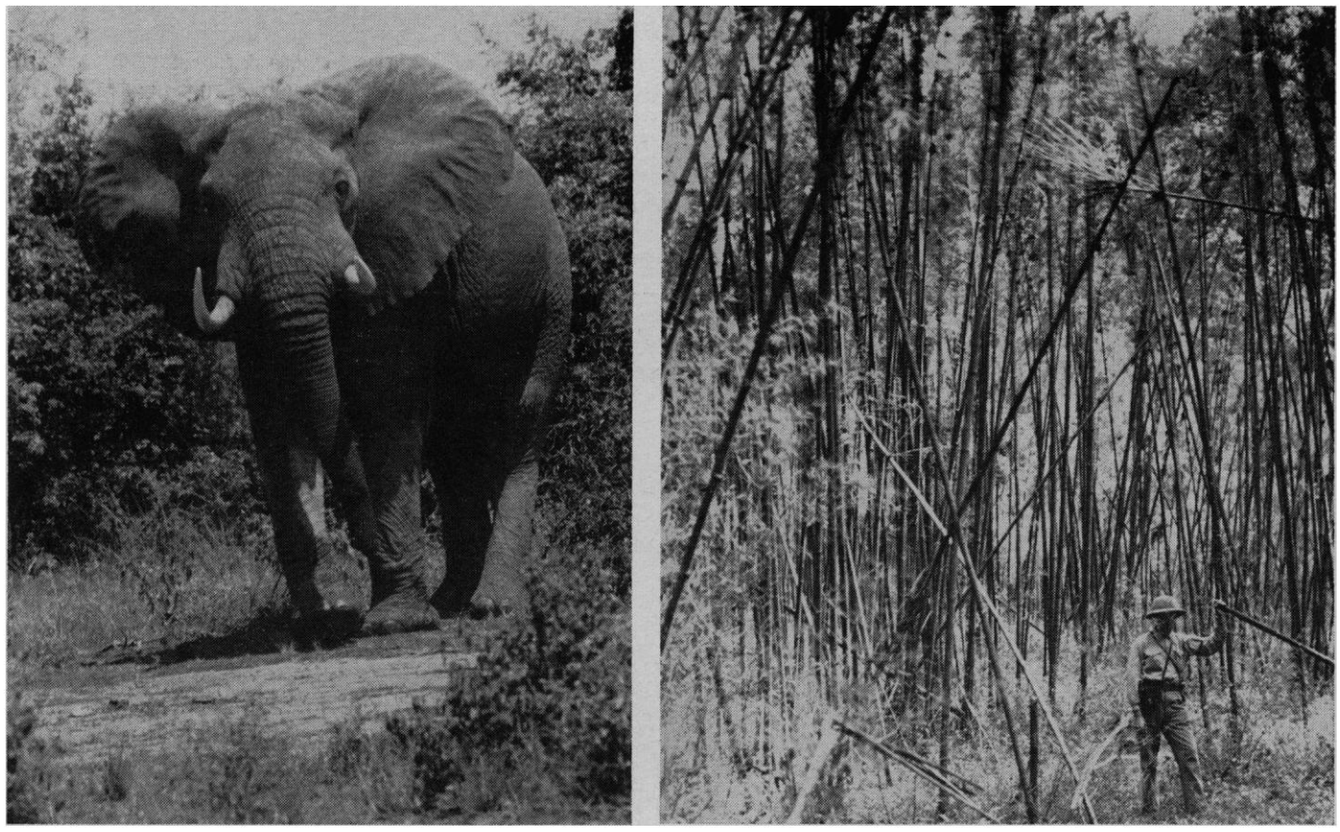
A forest of *Senecio Friesiorum* at an altitude of about 9000 feet. At this level one finds the great gorillas that are endemic to the region.

Protecting Man's Habitat

The idea that nature must be protected is quite a recent one. Plato, it is true, 2400 years ago, described the erosion of the mountains of Attica and the ruin of villages and farms. He believed that the deforestation carried out by man was the cause of this erosion. But it is only during the last 100 years that many people have become aware of the degradation occurring everywhere and the need to counteract it. A movement has developed recently to check the disturbance of natural equilibria.

It is curious that the first attempts to protect nature were made from esthetic motives, and in the United States. In 1872 the American pioneers, captivated by the charm of the new landscape they had discovered in the Far West, wished to perpetuate the spectacle for their descendants. At the same time artists, tourists, and the general public were reacting against the standardization of the places in which they lived and were seeking relaxation in invigorating nature. From these desires grew the great national parks, of which the first was Yellowstone. Later, naturalists grew alarmed at the progressive transformation wrought in setting up human establishments, either agricultural, industrial, or residential. Today it is the biologists who, studying the problems arising from the disturbance of natural equilibria, have concluded that nature governs the stability of the entire human habitat, controlling not only the production of indispensable foodstuffs but economic and industrial enterprises as well.

Even among our contemporaries, however, there are many who remain ignorant of the problem. They do not realize that this is a fundamental question for our age, and that the future of our civilization depends upon its solution. They do not see that man is now disrupting the operation of natural laws and leaving to his descendants, through the destruction of plants and soil, the prospect of insufficient food and perhaps of widespread famine. Scientists are therefore insisting that everyone be informed and that defensive measures be taken without delay. But they also insist that any intervention be thoroughly studied *before* steps are taken to stabilize or reestablish equilibria. It is all too likely that improvised decisions may be the starting points for further and unexpected catastrophies.



(Left) An elephant in the Albert National Park. These and other animals abound in the forests and lower alluvial regions around Lake Edward. (Right) A bamboo forest, typical of the 8000-foot level in the neighborhood of Mount Visoke.

If we are to protect man's habitat we must first know and understand what it is we are trying to protect. That knowledge is still incomplete. This is particularly true of certain regions situated in the tropics. And the possibility of acquiring much of this knowledge is rapidly slipping through our fingers. We know that 110 species of mammals alone have ceased to exist in the last 2000 years. In 200 years 600 species of animals have declined to the point of extinction. And what about the plants that are subjected, every year, to the assault of land clearance and destructive fires? The plant world is suffering an alarming decimation. In the temperate countries wild plants can live only along the borders of roads and fields; in the hot countries the sun-loving species are propagated over degraded areas, which have been tremendously enlarged, at the expense of other, shade-loving species that are now rare.

For half a century the demands of an explosive world economy, careless of consequences, have posed a growing threat to the stability of the habitat of many living species, which are thus condemned to perish. We shall bitterly regret this when we become fully aware of it. Would it not have been a pity, for example, if the coffee plant had disappeared before we were able to exploit it? Are we sure that there are not other wild species capable of meeting man's ever-growing needs for plant and animal food? Do we not know that research to discover and develop species for such uses requires time? Such research must be carried out by generations of naturalists and biologists having at their disposal the data accumulated through the patient work of a long line of predecessors. Compare this with the speed with which the forces of destruction accomplish their work.

In phytosociological groups there exist species capable of surviving even marked disturbances in their natural medium; there are others, however, which live in narrowly defined habitats and disappear the moment those habitats are disturbed.

All of these questions must be examined in detail, and solved, and the answers must be generalized and applied the world over. Perhaps nowhere in the world can some of them be better studied than in the great region of the Congo watershed, and in no other part of the world can failure to find satisfactory answers have more far-reaching effects. I shall take as an example a region with which I am particularly familiar, since I was a member of the directing council of the National Park Institute of the Belgian Congo for more than 20 years. Let us consider the Albert National Park in Central Africa.

The Albert National Park lies in the high part of Africa, extending over a vast plateau at an altitude of 3000 feet. It is part of the vast chain of mountains which begins with Mount Sinai in Asia Minor, runs along the west bank of the Red Sea, and continues from Abyssinia through the district of the great lakes to Rhodesia and South Africa. The Nile flows at the foot of the western edge of this chain of mountains; its source is in them, and its valley follows what is called the Great Rift Valley. The Albert National Park occupies a section of this rift, between Lake Kivu in the south and latitude 1°N. It is wedged in the

bottom of this valley for a distance of nearly 200 miles. To the east and west it is literally walled in by the two escarpments of the Rift; the greatly varying gradients of these walls present a practically insurmountable obstacle to the migration of plants and animals. In the south the horizon is closed by the chain of the Virunga volcanoes (10,000 to 12,000 ft), and to the north by the mighty Ruwenzori massif (15,000 ft). The park is thus roughly divided into four sectors, that of the volcanoes, that of the plain of Lake Edward, that of the Semliki River, and that of the Ruwenzori massif.

Two of the volcanoes, Nyiragongo and especially Nyamuragira, are active. Nyamuragira illuminates the night sky with fearful red glows. The last outflow of lava was in 1948, and the cooling flows are in the process of being colonized by plants and animals. The oldest deposits are already overgrown with forest. At the level of the base of the volcanoes there is a mountain forest, at 4000 feet, which is dense and shadowy. At about 8000 feet there is a curious band of bamboo forest. At 9000 feet the *Hagenia* forest appears, with a typical undergrowth inhabited by a species of endemic gorilla, of very great stature and covered with thick hair. Higher still come the bands of subalpine vegetation, including *Lobelia* and *Alchemilla*, forming an amazing landscape of prehistoric appearance up to an altitude of about 12,000 feet, above which only lichens and mosses are able to grow.

The Lake Edward plain is of recent origin; it is in the stage of herbaceous colonization, with herbaceous vegetation gradually giving place to thornbush and *Euphorbia*. This vegetation is established on the alluvial deposits of Lake Edward. The grassy terrain has favored a tremendous multiplication of antelopes, but as the habitat has changed, the numbers have decreased; elephant and buffalo, which prefer more wooded surroundings, are now increasing. Carnivorous beasts such as lions, leopards, and lycaons (the Cape hunting dog) fulfill their role of natural selection, and sick or unfit animals are weeded out. Hippopotami inhabit the rivers. All these animals, protected as they have been for 30 years, live in absolute peace, untroubled by the presence of human beings, whom they no longer fear.

On the marshy banks of Lake Edward itself live countless flocks of birds, feeding on the great numbers of fish which inhabit the immense expanses of shallow water. The River Semliki sector, which links Lake Edward with Lake Albert in the north, consists of several parts. One of these is the Upper Semliki, consisting of vast expanses of grassy savannas. It was formerly inhabited by a rich fauna, since ravaged by hunting expeditions. Further north a forest section is still inhabited by several families of gorillas. As for the Ruwenzori, its summit reaches glacial levels at an altitude of 15,000 feet. It can be climbed, and here one may see the same bands of vegetation that one sees on the volcanoes, but in a still more impressive setting.

The great importance of the Albert National Park lies in the fact that it spans the very heart of Central Africa, in the region where the flora and fauna of West and of East Africa meet. We thus find here plants and animals of the two great African domains, the Congo and the Nile, at the limit of their range of extension, as well as numerous elements typical of neither of these domains but of Central Africa.

How did it happen that this vast territory was set apart as a reserve? During the latter part of the last century a few men of foresight began to realize the seriousness of the ever-present threats to man's habitat and to take steps to counter them. In 1891 Theodore Roosevelt set aside for public use 150 million acres of forest lands, the "forest reserves." Today they represent about all that remains of nonprivate forest in the United States. Two years later, in 1893, King Leopold II of Belgium, realizing that bush fires in the Congo were so intense as to be fatal to the natural vegetation, issued an edict forbidding them. This edict ended with the sentence: "If we consider the influence of forests on the climate and soil of a region, we must realize how important it is to foster the forest cover." (Leopold, like Roosevelt in the United States, was bitterly criticized by all those who considered the forests a hindrance that delayed exploitation of the earth and reduced the profits to be obtained thereby.) In 1889 this edict was extended by the establishment of big game preserves in Central Africa, the specific purpose being to prevent the destruction of the elephants. After a series of international conferences on the need for protecting African wild life, further decrees for the more general regulation of hunting were issued. Leopold wanted to establish in Africa a series of natural reserves similar to those in the United States, but public opinion was not ready for that step within his lifetime. In 1919 his successor, King Albert, during a trip to the United States, told the Belgian ambassador in Washington, Baron Cartier de Marchienne, of his wish to see a series of national parks created in the Congo, similar to those he had seen in America. Baron de Marchienne, himself an ardent advocate of conservation, gained the support of a number of American conservationists, among them John C. Merriam, then president of the Carnegie Institution in Washington, and the late Henry Fairfield Osborn, president of the American Museum of Natural History in New York.

In 1920 the American Museum of Natural History sent Carl Akeley to the volcanoes of Kivu to study the gorillas which had been reported there. Akeley succeeded in observing these extremely rare and interesting animals at close range and urged that they be effectively protected. Through his efforts and those of the U.S. ambassador in Brussels, William Phillips, and of certain Belgian officials, approval was obtained in 1925, for the creation by the Colonial Council of Belgium, of a national park at Kivu. Akeley met his death in Kivu a year later and was buried on the side of Mikeno volcano at an altitude of about 8000 feet, in the midst of the reserve which he had helped to create.

In 1929 a new decree extended the original reserve to include the entire region of the Virunga volcanoes and the plain of Lake Edward, giving the Albert National Park a total area of about 1 million acres. Later the Park was again enlarged and five other parks were created. The lands were state lands and could not be transferred. The inhabitants, where any existed, were evacuated after amicable agreement and just compensation. Only the Pygmies, the "Batwa," were allowed to live in the national parks, since they, in fact, contributed to the protection of the forests in which they lived.

Today the Congo is in the throes of establishing itself as an independent commonwealth. We can only hope that the new leaders of the region will not allow the destruction of all that which has been preserved with so much difficulty in these areas.