propose that the risk be measured with more regard for the nature of the work to be done than has frequently been true in the past. No satisfactory justification has yet been advanced for screening persons engaged in unclassified research, in say biochemistry, by the standards appropriate for screening those who have access to the details of war plans and advanced weapons. As a matter of logic, there is no question of security in unclassified basic research. There is a question of loyalty; both public opinion and the opinion of scientists would usually hold against the supplying of public funds to a scientist of established disloyalty. But demonstrated disloyalty, or even a strong presumption of disloyalty, is a different matter from security risk. Disloyalty is not to be tolerated anywhere, but stringent security precautions are appropriate only when the information to be guarded justifies the stringency.

The classification of basic research is likely to retard the development of both peaceful and military technology. Basic research thrives on the free interchange of ideas and information. The free discussion of research findings and methods allows criticism, permits the discovery of error, stimulates improvement, and furnishes the original clues which lead sometimes to the development of new weapons and more frequently to the development of peaceful applications of science. When the free flow of basic scientific information is stifled, technologic development must inevitably suffer, and the greatest loss is to the nation that enjoys the highest state of learning and the most advanced technology.

It is easy to overdraw the distinction between two such policies as the negative one we are criticizing and the positive one we are advocating, and perhaps we have done so. Nevertheless, there is an important difference in the effects of the two. Under a policy that attempts to maximize gains, we would encourage the interchange of scientific information; we would attempt to use as many people of high ability as we could, even though not all could safely be used in the more sensitive positions.

A policy that attempts to minimize losses leads to quite different attitudes and effects. A costly aspect of current procedures which seems to have been generally neglected in official circles and which would be largely obviated by a positive approach to security is the wastage of time and talent, the lowered efficiency, and the slowing of progress that result from the excesses of current procedures. We can afford the time that goes into the investigatory process itself. We can justify the money costs. But can we afford to have government service become less desirable, to diminish the effectiveness of research and development programs, to retard the flow of information to and among our own scientists, to deprive federal agencies of the help of consultants who possess important information and rare skills the agencies would like to use, or to base support for unclassified fundamental research on the political ideology of the investigator and his associates? The lowered morale, the lost time and efficiency, and the denial to the nation of the use of some persons of great talent add up to a bill of unknown but certainly large size, a bill we pay for our negative method of maintaining security. Were time, talent, and effectiveness so wasted for any other reason, those responsible would be considered guilty of sabotage of the first order.

A positive program of security can be developed. It requires boldness; it demands continued belief in the fundamental loyalty of American scientists, engineers, and industrialists and in their ability to keep the United States ahead of potential enemies. It would foster the development and effective use of the resources of knowledge, talent, and enthusiasm which can keep us ahead. Such a program would strengthen the democratic spirit of freedom and of progress which is the hope of the free world.

Human Ecology: A Problem in Synthesis*

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PEKING man, most ancient of our near kin, is not more than a million years old. The earth as a separate planet is at least 2000, perhaps 3000, million years old. The species of Pleistocene mammal to which we belong has been present for only the last 30 sec of the 24th hour of earth's existence. On this scale, agriculture and urban life are less than 0.5 sec old, while modern power technology based on fossil fuel compares with a very fast "instantaneous" snapshot.

We are an explosion. For the first time in earth history, a single species has become dominant, and we are it. The power and intensity of our pressure upon environment is without precedent. Our numbers increase at a net rate—conservatively—of 1 percent a year. This means a net gain of more than 50,000 a day, and doubling in a generation. This also means increasing demand for space in which to live and move and increasing demand for food and other necessities from the space that is left.

Man thus becomes his own rival, or rather the victim of his own rival needs. The modern landscape

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abounds in evidence of the resulting confusion. We do not know whether to cherish the forest as a source of essential raw materials and other benefits or to remove it for the space it occupies. We expect a river to serve as both vein and artery carrying away waste but bringing usable material in the same channel. Nature long ago discarded the nonsense of carrying poisonous wastes and nutrients in the same vessels. We underwrite the cultivation of marginal land in the face of surpluses which we pile up while millions elsewhere are underfed. We increase our consumption of water vastly but discard the water that falls upon our expanding cities and highway systems. At the same time our heavy machinery and other mass-production methods in agriculture are reducing the permeability of the rural landscape, adding more runoff to the waste of rainfall that occurs by evaporation owing to excessive clearing of the land.

In our concern to preserve freedom we ignore the long and painful struggle by which it was achieved and flaunt the safeguards our society has thrown about the dignity of the individual. In our desire to give every individual an equal opportunity we have neglected to take advantage of the differences between individuals which should enrich our society. We know better than to try to make a bird dog out of a mastiff or a greyhound. We secure the best trainers we can for promising horses and dogs but allow our ablest students to idle through our school systems. With the costliest educational establishment in the world, the products of our secondary schools are ill-trained in comparison with those of the Old World, and we are amazed when one of the latter wins a college degree here in a year. The teacher, who hands on the heritage of our society, has a status below that of doctor, lawyer, or successful businessman.

We deplore the increase of juvenile delinquency while doing little to combat the idleness, lack of recreation, and the flood of evil printed material which probably contribute to it. Vandalism in the New York park system alone runs to hundreds of thousands of dollars a year.

We apply science—aside from medicine—chiefly to the production of consumer's goods, while its application to the conserving of raw material lags behind, speeding up only when the pocketbook is pinched.

Yet in countless cases we have shown that we can, in our form of society, meet and deal with every one of the problems just enumerated. The trouble is that we do so, if at all, by a crude process of trial and error rather than on the basis of principle. Principles and methods for applying them do exist, or can be developed, for the kind of problems in question are ecological. Whoever tackles them, or however we classify them, they involve the relationship between *Homo sapiens* and his environment, physical, biological, and social. Thus they concern the ecologist.

There are several theories on how science develops, and a measure of truth in each. The classical notion has emphasized the importance of individual genius. Men like Joseph Mayer in his *Seven Seals of Science* stress the importance of a logical order of discovery, running the scale from mathematics and astronomy on to biology and social science. Recently we have heard much of the economic factor—science arising in response to urgent practical need. In beginning my discussion with a statement of such practical needs in the field of ecology I do not mean to exclude the importance of creative minds or the need for knowledge upon which to build. I merely want to make clear that modern society requires our services, whether it calls for them or not.

Nor do I wish to fall into the error that long beset medicine and still, in a measure, distorts sociology. Any study that concentrates only on what is wrong—whether it be bodily disease or social pathology—while neglecting the normal and healthy must fail. The ancients knew a great deal about disease but did not understand health. Modern medicine began when attention was turned to the structure and functions of the *normal* human body. I sometimes fear that much social science is still preoccupied, as ancient medicine was, with pathology. Too many students seem to feel that sociology is a matter of counting privies or crusading against abuses in our society. Of this, I shall have more to say later.

Human ecology is concerned not only with the present but with the past. This is assuredly one of the most challenging areas of research. Although archeology has been chiefly a source of intellectual and esthetic satisfaction, it is, I believe, far more generously supported than the study of present-day ecology. And since the present and future of any community are expressions of its past, we may expect the study of archeology and history to have a practical bearing on the critical question of man's future. For an example, what is already known of the relationship between human cultures, climate, and erosion in the Basin of Mexico furnishes more than a clue to its present problems. Similarly, enough is known of human vicissitudes in our own Southwest to make clear that the present policy of expanding economy in that area is suicidal. Let me hasten to add that a sound economy is possible in both areas but not in terms of existing practices.

Something of the span and complexity of human ecology is evident from the personnel of the panel in which this paper was originally presented. My colleagues included a zoologist who is also a limnologist and a student of climatic history; a botanist who is a working geneticist and taxonomist, with a lively interest in the origins of agriculture and domesticated plants; a geographer of catholic interests, deeply concerned with the record of primitive man and his activities in the New World; and a cultural anthropologist who has a firsthand knowledge of the processes within and among human societies as they relate to their subsistence base. What we all seem to have in common is an interest in process and, thus, in the past as a key to the present.

Each of us has his areas of most intensive study, but if any of us are specialists, it is in a very broad sense

of the term. Human ecology is not so much a specialty as a scientific activity which must draw upon a wide range of the specialties. What is important is the work to be done rather than the label. It is well to recall Ivor Richard's remark that any definition is simply an invitation to others to use a term in the sense we have defined it. No one is bound to do so, at least until there has been general acceptance. Had some of our pioneers in ecology understood this principle, we of today might have escaped some of the criticism and misunderstanding which, even among our biological colleagues, continues to haunt us and handicap our efforts.

The advantage of *human ecology* as a label does not lie in the dubious opportunity to set up new departments and professorships—always a temptation in our competitive society. The merits of this label are rather in the encouragement it offers to workers in seemingly unrelated fields to become better aware of one another and of common interests and responsibilities.

The historian James Malin of Kansas is almost unique in his profession in having made a thorough study of the ecological literature dealing with the area of his interest—the western grasslands. The economist Erich Zimmerman of Texas, in the early pages of his volume, *World Resources and Industry,* shows keen insight into man's ecological role. The same may be said of the geochemist Harrison Brown of Pasadena, who has recently published *The Challenge of Man's Future.* The book entitled *Human Ecology* by the sociologist Amos Hawley of Michigan is likely to be laid aside by the ecologist as an intricate study of modern institutions, unless one happens to note his enlightened discussion of the meaning of human ecology. How many of us know what the magnificent work in regional planning by Lewis Mumford and others owes to the pioneer efforts of the plant ecologist Patrick Geddes? More of us perhaps are aware of the influence of ecological interests and companions upon the statesmanship and philosophy of the late General Smuts.

With few exceptions these pioneering efforts have come from the other side of the quadrangle. Yet there have been efforts in the past from our own side. The venerable but lively C. C. Adams, one of the founders of the Ecological Society of America, has long had very clear notions on the subject and at least twice before has arranged programs on it, inviting social scientists to participate with us. Unfortunately, the limitations under which the Ecological Society operates did not permit the publication of any of the papers, effectively discouraging our colleagues in other fields from further efforts. This is no reflection on our able and devoted editorial staffs but rather an illustration of the meager financial resources of a society whose potential service to the common welfare is at least equal to that of other organizations that are handsomely endowed with headquarters, staff, storage facilities, and means for flexible publication policies.

For this unfortunate situation I have no immediate or spectacular solution to suggest. We must continue to turn out sound and meticulous research, as we have in the past, inspired by such examples as that of our president, John Potzger, who in spite of teaching and administrative work that would tax any of us, is producing an amazing amount of excellent investigation.

I am well aware of the handicaps under which many ecologists are now carrying on. Some of these handicaps can be lightened if we can establish more general confidence in ecology as a respectable intellectual enterprise. There still exists among our colleagues—even those within the biological sciences—a measure of uncertainty and misunderstanding about ecology. This attitude has two extreme manifestations. Least flattering is the view that the work of the ecologist is superficial at best and consists largely of an emphasis of the obvious. The other and more sympathetic view is almost as destructive in its effect. It is the view that ecology is important enough but requires such profound knowledge of all other phases of science, particularly of biology, that its study must be indefinitely postponed. This, of course, keeps it from being readily available to all but the most persistent of departmental students. Where either attitude prevails, it operates to keep ecology from getting into the introductory course where much of it properly belongs.

Now it is not possible to control the way others may feel about us, but it is possible to see that they do not misunderstand us. If this happens, the chances are that we have failed to *make ourselves understood.* As an aid to better understanding there is no substitute for clear exposition in speech and writing. Such clarity is not, as some suppose, a gift of the gods, but the product of hard work, attention, self-discipline, and, above all, constant revision. As it goes in the profession "the art of writing is the art of applying the seat of the pants to the seat of the chair."

Our discourse should be simple. Technical terms should be our servants, not our masters. Whatever we write or say, we should be mindful of its place in the general scheme of knowledge. I have been interested for years in having a journal of American science that would equal in quality and readability the British *Nature.* One of the obvious faults of our own journal *Science* has been that many of its contributions seem to be of too narrow technical interest. Actually this is because most writers do not start out with a clear explanation of what and why. Yet the present editor, Duane Roller, tells me that when articles do come in with such good introductions, experts to whom they are referred generally say "Cut this out. Everybody knows it." Everybody in this instance means the specialist. It is not only the modern poets who use a special form of language. A consistent policy of making ourselves more widely palatable and better understood might perhaps make us more appreciated.

Of the utmost importance is the need to see that the ecologist's point of view is embodied in elementary science teaching. This is more than a measure of self-preservation for our discipline—it is a matter of re-

sponsible citizenship. The 75 to 90 percent of our beginning students who take no further work in biology will presently be faced with decisions in their own communities, whether urban or rural, that can be much more intelligently made if those students understand a few ecological principles. Yet if one examines the textbooks and syllabuses used in many introductory courses, one finds that ecology, if there is any, has been dragged in by the heels, when it should have been used to give perspective to the whole course. Many, if not most, courses are set up as a slow and dramatic unveiling of the process of evolution, yet fail to make clear the profound ecological basis upon which it rests.

There should at least be a protective statement of the kind used in detective stories—"Any resemblance to ecology, living or dead, is purely coincidental." Again, I would be the last to quarrel with the magnificent work now being done in such fields as intermediate metabolism and the ultramicroscopy of the cell. But the whole still remains more than the sum of its parts, and the parts should not be allowed to obscure the entity in the eyes of any beginner.

I have mentioned the matter of citizenship. Here the ecologist, not only as a teacher, but as a participant, has one of his greatest opportunities. It is an open secret that our Government failed to utilize its biologists as well as it might have during World War II. Using biological—largely ecological—techniques, the British registered some notable achievements. One of my former students was responsible for very effective tactical successes in the Pacific area, thanks to his ecological training—not because he was recognized as an ecologist, but because his military rank made it possible for him to try novel and unconventional methods.

One reason for the formation of the AIBS was our feeling that in matters of high policy our brethren in the physical sciences seemed to be regarded as the spokesmen for all science. Like good children, we were not to speak unless spoken to, and then largely on specific problems of medicine and agriculture. Here again, as in academic circles, the fault may be partly our own.

Perhaps we need to remind ourselves that the long road to constructive statesmanship begins at the local level, for the ecologist as well as for the future senator. I have yet to study a community that could not use, in solving its immediate problems, the kind of assistance an ecologist is peculiarly able to render. One can reach out at random for examples. Take the problem of juvenile delinquency. Like that of communicable disease, it relates to the availability and distribution of space. Where there should be at least an acre of recreational space for 100 people, none of our major cities can approach this figure. Even Boston, which is beginning to look like the Paris of the New World, has less than half this proportion, or did at last accounts. With a national population that has increased more than 50 percent in the past half-century, and with our present augmented birth rate, the problem of urban encroachment on the rural landscape is becoming more and more acute. Who can see better than the ecologist what this involves in terms of functional community relationships—space, waste disposal, access, suitable land use, growth, and the general organic equilibrium so essential to the intangible values that make life a decent enterprise?

This raises a delicate problem for the scientist who is likely to think of public affairs as involving partisanship. There are, of course, certain risks inseparable from American citizenship, one of them being the willingness, when necessary, to stand up and be counted. The scientist, like the rest of us, must be prepared to take the duties, as well as the privileges, of our system when the occasion requires him to do so. However, his position is in some ways unique, justifying his avoidance of partisan politics insofar as possible. It is the role of science in political life to supply light rather than heat. There is usually plenty of the latter. There is seldom enough unprejudiced, impersonal evidence from competent sources to guide those who have to make decisions, either at the polls or in government. So far as information of this kind can be had, it is the obligation of the scientist to furnish it.

Since the ecologist should understand the dynamics of his community, he is in a position to furnish not only information but guidance in its use. In this he will need intuitive good sense, of course. But he can also draw upon a considerable body of principles, if he will acquaint himself with the viewpoint of the modern cultural anthropologist. The concept of culture patterns and its corollaries as developed by this group of workers will furnish him with a practical means of analysis and operation.

I discussed this concept as it relates to ecology informally for the layman in a little book called *This Is Our World,* published in 1937 and now out of print. A brief but somewhat more formal account is to be found on page 300 of volume II of *Medical Physics* edited by the late Otto Glaser. It is conveniently presented from the standpoint of the anthropologist in the well-known book *Culture Patterns,* written by the late Ruth Benedict.

The essential point for us is that man is functionally related to his environment in terms of the characteristic pattern of his particular culture. The power of this idea as an instrument of analysis and operation lies in the fact that it shifts the focus from the individual to the general framework of accepted practices and values from which the individual derives his sanctions. The concept of culture patterns leads us also to a study of the functional controls of any community under observation. Although it does not eliminate the factor of individual responsibility, it reveals the means that every culture possesses of modifying its own form and thus gives an efficient approach to better adjustment.

Charles Jones, graduate student at Yale, has reported a case among a group of Navajo where every effort had been made by conventional means to induce

the Indians to adopt certain improvements in land use essential to a sound economy. These efforts were fruitless until the new practices were put into effect by an ex-rodeo rider who lived among them and whose horsemanship had invested him with great respect in the eyes of the Indians. Similarly, Mexico has some of the most enlightened forestry legislation on our continent, but it remains impotent until something can be worked out that makes sense to the Mexican in terms of his own culture. In our own highly industrialized culture all of the sound and fury over water pollution accomplished little until organized business, industry, labor, and sport sensed a common threat and began to join forces on the problem. The task still remains of awakening some thousands of municipalities to their responsibility. It is significant that Milwaukee, with its German cultural heritage, has been a pioneer in abating pollution and utilizing waste.

Many of the ecological maladjustments in our own society are urgent, costly, and aggravating in the extreme to those who sense them. It is a constant temptation to expend one's energy in condemnation and crusade and to satisfy one's instinct for moral indignation when the issue seems so clear-cut. But the constructive procedure, as in any ecological problem, is to analyze the processes with which we are dealing, determine the factors involved, and then go to work. In practice this means that conflicting interests and centers of influence must be identified. Those who represent them can often then be induced to state their respective cases and listen to one another. More frequently than not, in my experience, this leads toward constructive action. It may not come at once. Obstacles and delays are to be taken as a matter of course. Human beings are more refractory than the so-called "lower organisms," and time is less important than trend. Patience, persistence, good communication, and good nature are essential and, in the long run, most effective.

Lest it be thought that these suggestions are academic, I might explain that I have seen them used to improve ecological legislation, administration, and community action in widely separated parts of the United States during the past two decades.

For example in 1937 the farmers of Oklahoma descended upon Governor Marland demanding some kind of legisation that would enable them to combat soil erosion, which had become a prime menace to agriculture. The governor appointed a committee whose chairman was familiar with the idea of culture patterns. The American culture pattern seemed during the 1930's to be in a state of flux, with traditional responsibilities being unloaded upon, and cheerfuly assumed by, a benevolent federal government. Yet even Russia, under rigid controls, was evidence that every culture has its own momentum which has to be reckoned with. It can be guided and modified by its own mechanism, but it cannot be disregarded. And so, although the climate was favorable to radical innovations, the committee—with competent advice—drafted a law authorizing the voluntary formation of local districts with technical advice to be supplied by Washington. For this there was plenty of precedent in the American pattern.

It so happened that the governor was at loggerheads with his legislature, whose able leader viewed with a jaundiced eye anything that emanated from the office of His Excellency. The latter was in sympathy with the then national administration, while the legislature was extremely conservative, and particularly suspicious of the lavish federal expenditures being used as an antidote to hard times. A bitter fight was in prospect, but it was avoided by quiet and reasonable explanations, based strictly on the most traditional American practices and upon the firsthand knowledge that the chairman had of ecological conditions within the state.

Self-interest is a strong element in American culture, but so is self-respect. A practical politician is usually grateful for an issue that is strongly rooted in the scientific realities of the situation, provided that we translate it into terms he can understand. Businessmen are interested in the character of the communities in which they live as well as in the profits they can get there. And a satisfying community is largely the expression of sane ecological conditions. Who can better analyze and explain such conditions than the ecologist, trained as he should be to read the landscape? But he must be equipped to analyze the human community and understand the forces at work within it as well.

Once the ecologist expands his analysis of such phenomena as destruction of soil or native vegetation, or of disturbance of the hydrologic cycle so that he sees them, not in the personal terms of foolish individuals or bad laws, but rather in terms of the basic structure and values of his society, he is in a position to be highly effective. And he will be even more so as he learns to detect examples of good ecological adjustment. These are more frequent than he may have thought. For him these are as useful as an architect's drawings to a builder.

When we as a profession learn to diagnose the total landscape, not only as the basis of our culture, but as an expression of it, and to share our especial knowledge as widely as we can, we need not fear that our work will be ignored or that our efforts will be unappreciated.

There is no adequate defense, except stupidity, against the impact of a new idea.—P. W. BRIDGMAN.