RISK-TAKING CONSIDERED IN A COMMUNITY ECOLOGY FRAMEWORK

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TABLE OF CONTENTS

TABLES

FIGURES

ABSTRACT

Advanced societies of the world have developed a common rule for guiding collective action. It says human life or existence is to be preserved. The uncertainty associated with a given situation regarding loss of life (or life-supporting resources) is called risk. The larger body of knowledge and theory encompassing such living systems is best called community ecology.

A straightforward application of the rule suggests that acquisition of control over sources of risk should lead to growth of a special kind. The best-informed actors in the community tend to choose positive sum games. Thus, as long as knowledge about the ecosystem increases, longevity is enhanced, biomass increases, and the community is enlarged.

However, the life preservation rule is not applied consistently. For example, risks incurred through acts of one's own choice are much greater than those allowed to be imposed by others. Also, risks of disaster attributable to human projects, including induction of prominent diseases like cancer, are now to be reduced to a miniscule level regardless of cost.

Unbalanced response to risk is ascribed to the hierarchistructure of modern institutions; it acts as an amplifier producing extraordinary efforts at life-loss prevention in instances where the institution may be at fault. Inconsistencies are magnified further when communications media dwell upon attention-gaining issues.

The endangered species designation illustrates another peculiar feature of the trend. Thus spatio-temporal distributions of population in the wild portions of the biosphere are affected by an extension of the preservation-of-life rule, and deviations from it. The original intent was to counterbalance the effects of man's predation and intracommunity competition, but the values regarding acceptable risk evident in the communications media are now being incorporated into law. The result will be new ecological phenomena. Survival, even among wild species, will depend upon human attention, as indicated by the content of communications.

Undesirable change (e.g., destabilization) in ecosystems is created by obsessions evident in human communications. This can be serious because technologically advanced societies have predilections which are diffusing rapidly to the others, thus becoming universal.

Since May 1970 ("Earth Day") a concerted demand has arisen for a more rational and integrated policy for dealing with natural resources and the living environment. The subsequent United Nations conferences, Club of Rome reports, and studies oriented to national policy have forcefully reminded the world of its need for achieving a stable state within a few generations.

The flurry of independent, mainly national, programs launched since then have produced increasing conflict between their respective objectives; we find one undoing what the other is endeavoring to achieve. The unifying perspective that is desired should suggest _how_ to make tradeoffs, _where_ it is feasible, and _when_. It should also suggest what kinds of goals for existing managing units are henceforth appropriate, the accounting systems they need to develop, and the balances to be made when appraising projects before they are initiated. The perspective should also stimulate managerial improvements in the operation of projects after they have been launched.

The best term I can find for this corpus of principles is "community ecology." Intuitively, the meaning of the phrase encompasses the full range of concepts from general ecology, human ecology, social ecology, urban ecology, community organization, community planning, and environmental design. Its semantic space lies between the better explored domains of macro (aggregate) analysis and micro (i.e., individuals, households, and simple organizations) analysis.

The translation of issues regarding further development into the language of ecology is not expected to achieve the rigor of mathematical modeling, but it does establish a context within which a wider range of questions may be raised and subjected to empirical investigation. In a few instances, ecologically based arguments can offer quite new challenges for investigation; when it appears, such a set would be given the highest priority for attention.

Most significant over the next decade, perhaps, is a cluster of problems that are not labeled "risk assessment." What follows is an attempt to reshape some current paradoxes by superimposing ecological, or living-systems concepts upon the earlier systems approaches (for living systems, see Miller, 1978). The following issues are taken as salient representatives of public controversies that must be resolved soon.

The Electric-Power Dilemma. How does one appraise the relative risks to human life and activity from the installation of the next wave of electric generating plants? Nuclear fuels are resisted by the most strongly held opinions, although the principal alternative (coal) releases several fold greater amounts of roentgens into the biosphere, while also producing airborne acid sulfates--an agent which seems to produce more short-term ill effects--and carbon dioxide, which threatens global climatic change from its accumulation. Solar advocates are numerous, but admit that solar power technology will not be ready for mass production of electrical power for some time. Which then raises the question: What happens to the risks in urban habitat if the demand for energy is not fully met 10 percent of the time? Or 50 percent of the time? (Gibson, 1977).

<u>The Hydrocarbon Fuel Crisis</u>. The population of automotive vehicles is growing almost three times as fast as human population despite the very strong expectation of a rapid diminution beginning in about 20 years. Liquid fuels can be prepared from biomass, but then the vehicles will compete directly with humans. The principal paradox regarding risk is that much greater expenditure of energy and effort is devoted to the prevention of losses from air pollution than from accidents. Why? (For some suggestions, see Slovic and Fischhoff, 1977).

<u>The Environmental Toxins Controversies</u>. Food-and-water additives, and trace pollutants in the atmosphere, have now displaced pesticides as matters of serious public concern. But what level of contamination becomes too dangerous? What should be done about cigarette smoking, which has a thousand or even a million times greater effect than those newly identified mutagens, teratogens, carcinogens, hallucinogens, etc.? People willingly accept many

kinds of risks in their natural foods much greater than the additives (Hall, 1977).

Until very recently the discussions of the degree of risk, and the levels at which risk became unacceptable, were scattered throughout the scientific and professional literature. Risk affecting others is a daily concern of medical people, of designers of new artifacts, of actuarians working for insurance companies, the officers of vessels and aircraft, and the managers of enterprises. Risk is an occasional concern of economists, psychologists, and philosophers. A systematic synthesis of these considerations has been accomplished for the first time by William D. Rowe in his recent book, <u>The Anatomy of Risk</u> (1977). The arguments presented here are already implicit in that seminal work, or have been elaborated there in extenso. This effort constitutes primarily a translation into ecological framework with an updating of several years, taking into account added information, followed by inferences regarding best policies for long-range planning.

In addition, I contend that <u>the predispositions and ethical concerns of many scientists--indeed the norms for their professional behavior--run counter to the ecological imperative that our system should be guided to a stable steady state</u>. A new balance of judgments is needed to achieve the desired stability.

Responses to Reported Risk in Advanced Societies

Death for the individual is the only thing that is certain, but a society is "advanced" if it has created technologies to postpone deaths. One of the very best indicators of the degree of social advancement is the life expectancy for the human population. We note also that this reduction of risks to individual survival is very strongly associated with power to intervene in the environment and to control productive behavior in other societies. For example, the power associated with wealth accumulated by long-lived peoples in the temperate zone induces millions of people in the distant tropics to spend their lives cultivating coffee. Socialist countries in the same latitudes with similar life tables find means outside of the market to induce roughly equal numbers to spend their lives cultivating sugar cane.

It is curious that this underlying belief about the desirability of long life has come to be dominant, regardless of the political order, because it was not always so. Only a few centuries ago the power (i.e., dominance) of an elite was associated with the belief that individuals might sacrifice their life in this world in order to gain a better one in the next--such qualities as merit, or dignity, or respect were to be enhanced or optimized. However, in advanced societies today the principle is that human life or existence is to be conserved. In some critical instances, encountered quite often in medicine, we find lack of consensus as to whether longevity or living is the central criterion, but for most public decisions the outcome is the same. Anyone behaving otherwise is either unethical, insane, or criminal.

The concept of risk, therefore, reduces ultimately to a special set of ecological considerations. They are different from those that prevail in pre-human living systems, and also from those that guided or ordered earlier forms of civilization. The emphasis upon the conservation of human life rather than assurance of reproduction may seem "unnatural," but it is ecological nonetheless.

Such assumptions are rarely allowed to be recognized when we speak of risk. For the present, risk is defined as the "uncertainty of loss." Uncertainty is an information measure; it derives from interpretation of prior messages and remembered experiences. Loss refers to <u>assets</u>, including physical function (risk of injury) and the remainder of a lifetime (risk of death). Thus, both degree of uncertainty and loss can be put into quantitative form:

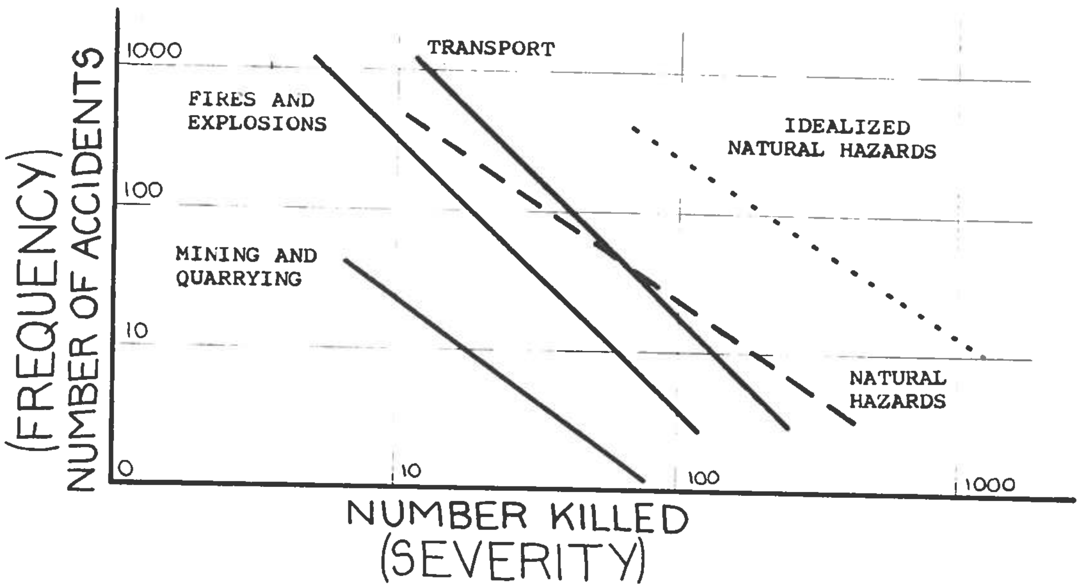
$$\text{Risk} = f(H \times L) \qquad \begin{array}{l} H = \text{information} \\ L = \text{loss} \end{array}$$

Therefore, for a particular action, it is possible to estimate the likelihood of various kinds of loss, comparing it with the likelihood of gain. This can be done for each choice, and some alternatives can be ruled out immediately. By making further assumptions about equivalence of gains and losses, it is possible to construct a cost-benefit appraisal.

According to this procedure for "rational" choice, many risks are worth taking but some are not. In the real world, however, there appears to be a lack of consistency because glaring anomalies of "irrationalities" exist, even at the level of public consensus. Some of these discrepancies from the "rational" are of particular interest because they hinder an approach to a stable state; in other words, they greatly increase the likelihood of very large-scale catastrophes.

An example is to be found in attitudes toward disaster prevention itself in modern societies--some specifiable disasters are vastly overrated. The prevention of such disasters is now assigned the same amount of attention and effort as a hundredfold greater number of casualties taken one at a time (Rowe, p. 323). This bias against the clustering of injuries and fatalities is most evident when designing new facilities, such as power plants and airports. The effects of this focus upon disaster prevention are illustrated in Figure 1, which sums up the postwar experience in the United States. (The "idealized natural hazards" is expected if no risk aversion were possible.) The resultant shifts in the valuation of human life are shown in Figure 2. This "revealed preference" approach to risk aversion is now firmly imbedded in safety standards enforced by government.

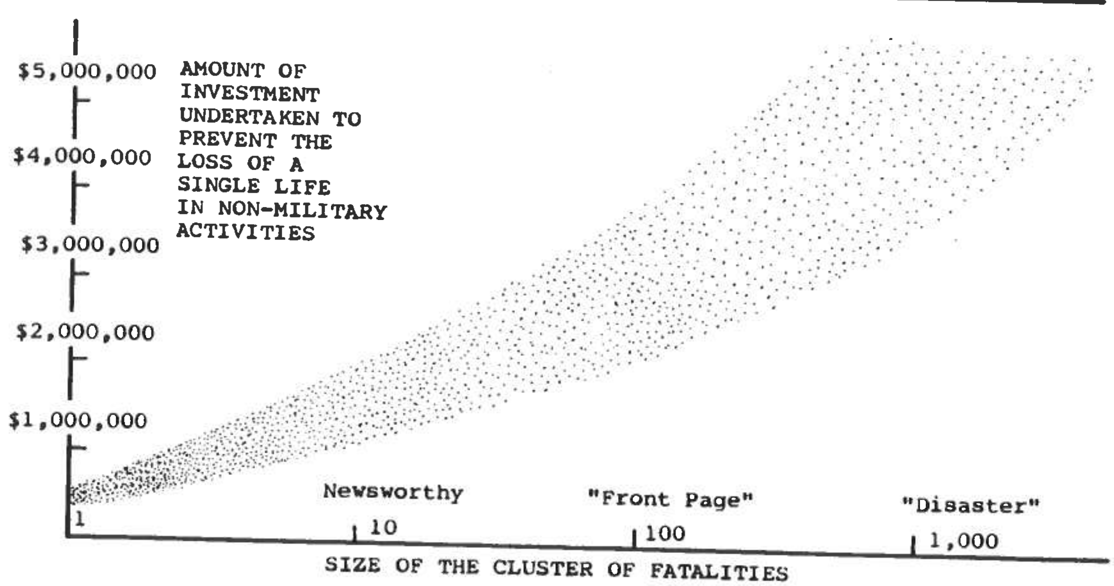
Figure 1



SEVERITY vs FREQUENCY: ACCIDENTS IN AMERICA

Figure 2

THE SOCIAL CONCERN BIAS ON LIFE-SAVING EFFORT



When attempting to explain this phenomenon it is important to make a distinction from the outset between voluntary and involuntary risk-taking (Starr, 1969). People willingly undertake quite high levels of risk (e.g., a job in underground coal mining or deep sea diving) when the rewards are commensurate. People object strenuously if much lesser risks are imposed upon them without their knowledge, even when the level of risk is much smaller than those to which they expose themselves. Strong objections are also made when imposed risks are noticeably inequitable. According to the data collected, disasters are predominantly the result of involuntary risks (high winds, floods, earthquakes, explosions, etc.), but a few--as in coal mining and working on ships--are voluntary to a large degree.

The difference between the voluntary and involuntary risks accepted is exacerbated by the way they respond to rewards. Otway and Cohen (1975) reevaluated Starr's original observations and estimated that for voluntary situations:

$$Risk_1 \;/\; Risk_0 \;=\; k\left(\frac{B_1}{B_0}\right)^{1.8}$$

B=net benefits or rewards expected

However, the exponent approximates the sixth power for involuntary risk. Thus, projects involving quite large rewards cannot be undertaken in developed societies if they are believed to add to the likelihood of catastrophes by a very small amount. As a result of these recently evolved propensities for risk aversion it has become virtually impossible to build the large new power plants, oil refineries, and chemical facilities need to meet demand in developed countries.

Bio-ecologists are used to observing a different response to risk (Keyfitz, 1977). If humans were to be completely passive and fatalistic, we would expect a simple relationship to hold (this is the "idealized natural hazards" relationship shown in Figure 1). However, animals take some defensive measures and people take many more. Communities introduce lightning rods, firebreaks, levees, cyclone cellars, and steel skeleton structures. A given size natural disaster will then very often be prevented from inflicting large-scale casualties. Well-organized communities (mainly middle class) suffer far fewer casualties from the same physical stress than those with lower levels of education and collective assets (O'Keefe and Westgate, 1977).

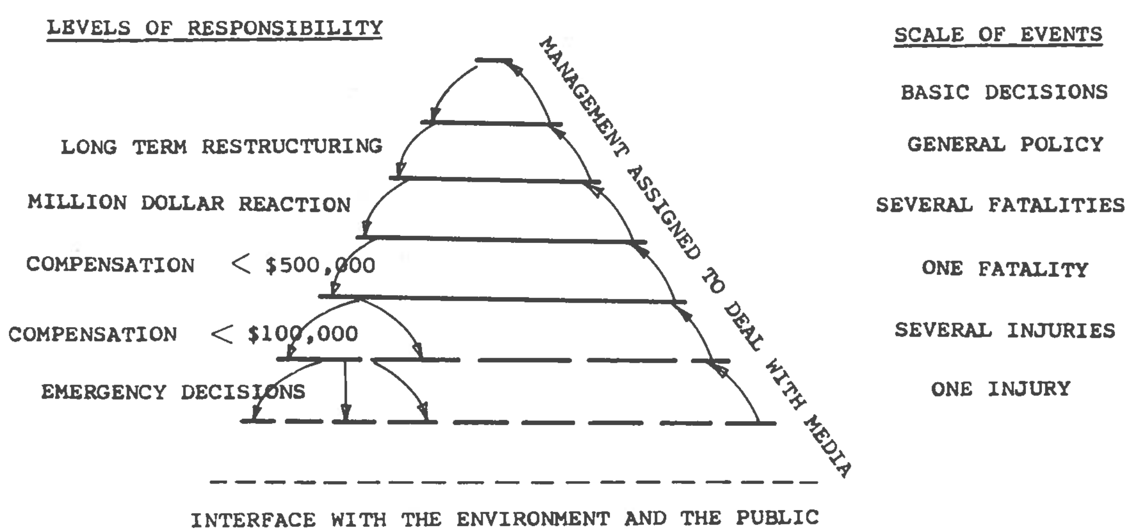
Reasons for Overemphasis upon Catastrophes

People can also prepare defenses against injury from the operation of vehicles and other artifacts, and an organized society can address itself to the redesign of the artifact itself. Each offending part or feature is refined until its malfunctions fall below a preset frequency. In a technologically advanced social system professional attention is directed to the safe design of artifacts; most specifications are set jointly by committees with members representing producer, supplier, and public interests.

Equally important in the prevention of severe accidents has been the emergence of a style of corporate control which decentralizes lesser decisions, so that each level upward in the hierarchy is assigned tasks and accepts responsibility for successively larger-scale activities. An accident with several fatalities is usually brought all the way to top management; it frequently means that they will have to face the embarrassment of some kind of public hearing (Figure 3).

Figure 3

BUREAUCRATIC HIERARCHY AS AMPLIFIER OF CONCERN DUE TO SIZE OF INCIDENT



This prospect reflects back upon the relationships they have with their juniors. Therefore, all levels in large organizations go out of their way to prevent large-scale failures in their product or service but remain tolerant of individualized, small-scale accidents. Separate one-at-a-time events are hardly ever linked to each other and traced back to the system.

The glare of publicity spreads trauma and multiplies economic loss as clamor for government investigation is raised and litigation escalates, so the responses of management can hardly be regarded as overreactions. Increasingly the conservative response is adopted--large firms practice ultra safety against attention-gaining failures of artifacts. The regulatory agency is affected the same way, so that any producer is prodded by civil servants if it fails to be responsive. If both are slow, critics among the public can gain attention when the issue fits the formula for what is newsworthy. Size of loss in an incident is a reliable index of significance among journalists, so the overemphasis upon catastrophe prevention can be traced eventually to the criteria which determine what appears in the news in a democratic society. Socialist authorities long ago decided that large accidents need not be reported unless foreigners are involved, therefore we expect much higher frequencies of major accidents within their borders. Unfortunately, the data that would confirm this hypothesis are not reported, and quite possibly may not even be collected.

Ultra-safe design is very expensive. It can add 10-30 percent to the cost of production of mass-produced items like toys or trucks or chemicals. Developing societies, with a greater tolerance to risk by a factor of 6 to 20 (Rowe, 1977, p. 323), thereby gain a significant competitive advantage. They can accept not only the "dirty industries" but the dangerous ones, because the danger is still considerably less than that imposed by the reduced level of public services brought about by poverty. Multinational firms in particular find it profitable to move production overseas as a consequence of disaster-prevention standards.

More important than the shift in industrial structure of the economy is the wastage of scarce capital. Less is available to meet greater risks from the supercatastrophes from natural sources. Climatologists and geophysicists argue that presently our "best" data (covering the span of 1945 to 1975) are faulty because it includes a long period of "extraordinary quiet" for the physical environment, so our depending upon them is likely to lead to significant underestimation of the frequency of major catastrophes in the more turbulent times ahead (U.S. National Research Council, 1976). Instead of moving toward a steady state, every investment in artifact safety draws upon the stock of capital. Shortages of capital enhance vulnerability to high-stress situations which could easily result in a series of punishing oscillations--a terrifying collapse followed by reorganization and recovery only to be hit again by system breaks greater than the capability to manage.

Having identified the consequences of a misallocation of resources to design, we must enquire into the social mechanisms that maintain the bias--the "social trap" that prevents balanced attention to risks (Platt, 1973). The public is schooled not to trust personal experience and intuition alone; it senses danger on the basis of the frequency of sharp reminders brought to its attention, mostly through the mass media. The media, being competitive and properly alert, try to pick up every possible new threat to the social order or to individual welfare. Threats are newsworthy and merit headlines, while equivalent opportunities for benefits, including the repeal of threats publicized earlier, are often buried in the back pages or in nonpeak viewing hours. The current standard news formula requires that salient events, even if only anticipated, are referred to many times, and are thereafter weighed as significant by the public. Other events which have equivalent impact upon society but are less memorable are virtually ignored by the media. Quite reasonably, the citizenry in an open society tends to judge threats and opportunities on the basis of recency and the evaluations reached through personal discussions; statistically, repetition of mention within an accepted category creates reminders, or recency.

Perceptions of riskiness were surveyed and evaluated by Slovic and Fischoff (1977). They found that a relatively well-informed public would demand substantially lower levels of risk if it is (a) imposed from the outside or involuntary, (b) not controllable through better organization, (c) new and unfamiliar, (d) unknown in its properties, and (e) has effects continuing into the next generations. Any emphasis upon these five factors in the messages conveyed by the mass media, especially when reinforced by frequent references to specific events, creates perceived risk a hundredfold or more greater than measured risks (Fischoff et al., 1976) (Table 1).

Table 1

Nonchemical risks of cancer

Risk of cancer, fatalities per year × 10^{-5}	
Cosmic rays	
One transcontinental flight per year	0.05
Commercial airline pilot[a]	5.00
Frequent airline passengers	1.50
Other radiation	
Average U.S. diagnostic medical x-ray	1.00
Sea level natural background	1.50

a 50 hours per month at 35,000 feet

Some recreational activities involve relatively high risk . . .

Risk of death × 10^{-5} per year	
Football	4
Auto racing	1200
Horse racing	1300
Motorcycle racing	1800
Power boating	170
Amateur boxing	2
Skiing	3
Canoeing	40
Rock climbing	100
Sunbathing (curable skin cancer)	500
Fishing (drowning)	1.7
Drowning (all recreation causes)	1.9

. . . as are many occupations

Risk of death, × 10^{-5} per year	
Coal mining, black lung disease	10,000
Coal mining, accident	1,500
Airline pilot, accident	50
Typical jet flying, air accident	10
Manufacturing, total	5
Fire fighters	1,000
Steel workers	60
Railroad workers, accident	400

Source: Cancer and Chemicals. Chemical and Engineering News 56 (1/30/78) p.31

Superimpose upon this "awareness based upon frequency of newsworthy items" the suspicion that the worst is being "covered up." It is to be expected then that certain rumors, clues, and inadvertent revelations will be assigned exaggerated weight. Thus, most people tied to the popular media feel tossed from one crisis to the next--toxins in the environment, energy supply shortages, the accumulating supply of radioactive nuclear wastes, anticipations of earthquake, crime in the streets, and so on.

A Living-Systems Framework

What should be a tolerable level of risk for a prudent decisionmaker, independent of fads, crazes, propaganda, and historical bias? The comprehensive work, Living Systems by J. G. Miller (1978), notes that deciders for societies take different amounts of risk than those for organizations, groups, and individuals. This matter of levels, or subsystems, within living systems has caused huge confusions; it is the source of the difference between voluntary and involuntary, as already introduced, and of several others less clearly differentiated.

The risk over which a person has no control establishes his maximum life expectancy. At the present time an active adult male can expect to survive to the age of 78 to 81 if he is in average health; a female typically can expect to live 2 to 4 years longer. The mortality rates for working adults of voting age are very low.

The odds against survival are 1 in 200-500 over the course of a year. The amount of risk that an insurance company or an extender of credit would consider reasonable should be small as compared to these ordinary hazards that cannot be avoided. A more explicit criterion would say that it should not exceed the year-to-year variation in mortality rates; that would amount to something in the range of 1-10 percent of the annual rate (for some ages in America accidents are more important than disease as the cause of death). A person would thus be deemed prudent if he avoided risks in excess of 5×10^{-5} fatalities/year (Table 2).

Table 2

Varieties of Risk at Respective Levels of Organization

Levels of organization	Common sources of injury	Expected causes of death	Normal life (years)	Nonsurvival likelihood (annual)
0. Molecules	Dissociation, ionization	Heat	10^{7}-10^{10}	10^{-9}
1. DNA-RNA-protein	Loss of energy source, dehydration	Sterilization	10^{9}	10^{-9}
2. Cell (e.g., neuron)	Poison, rupture starvation	Nutrition lack, predation, aging	10-100	10^{-1}
3. Organ (e.g., brain)	Function loss, stimulus deprivation, overload	Disease, accident aging	1-100	10^{-1}
4. Individual (e.g., human)	Loss of status, function, freedom	Aging, disease, accident	70	10^{-2}
5. Group (e.g., primary)	Separation, distrust, mental illness, poverty	Divorce, disease, accident, aging	10-100	3×10^{-2}
6. Community (human-dominated)	Schisms, reduction in economic base	Loss of supports, war, accident	30-1000	10^{-2}
7. Organization (e.g., bureaucracy)	Resource reduction, feuds	Dissolution, bankruptcy, amalgamation	30-100	10^{-2}
8. Society (e.g. nation)	Input reduction, conflict	War, assimilation	100-1000	3×10^{-3}
9. Biosphere (paleogeologic era)	Epidemic	Cosmic causes	10^{6}-10^{8}	10^{-7}

With this ecological, or living-systems, framework in mind one can make a case for the following principle for planning:

> Every program for intervention, and every major project contained within it, should be scrutinized for its effects at the various levels of organization. No new initiative should significantly increase the likelihood of collapse. Thus the highest priority is given to the prevention of war, famine, massive epidemics and other system breaks. At each lower level perturbations from intervention should be kept small as compared to the measured normal range of variation. The impact statements so produced should provide reasoned assurance for maintaining stability. What this criterion conserves is human experience, rather than longevity, making it the dominant force in the ecosystem. An outgrowth of the scientific humanism of the last generation, it should reign until too many new paradoxes emerge.

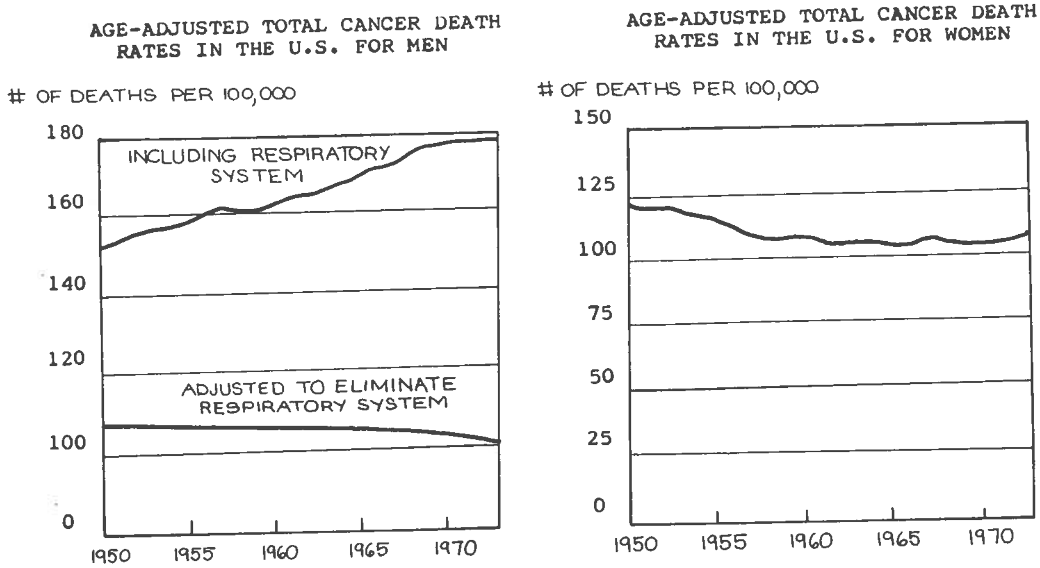
The endangered-species issue provides an example of the shift in viewpoint. The normal risk is determined by the estimated rates of extinction at equilibrium--species must come and go as the RNA-DNA-protein sequences (genes) continue to populate an earth with locally changing conditions. Certain species which are endangered by small population size and fragile supports that could disappear due to the intervention of man should not automatically be the occasion for alarm, but only if there is a substantial decrease in survival expectancy of the community as well. The snail darter by itself would not be able to halt the development of the Tennessee Valley, but it might if it was an indicator of many other species which would follow it into oblivion.

Indeed, the need to find a new global steady state with a high expectancy of life for individual humans (achieved by balancing safety measures and minimizing overall risk) may actually require a higher extinction rate for species during the transition. The steady state we seem to be seeking with our policies for risk-taking seems to imply that the human race will account for a much higher proportion of the total biomass sustained in the biosphere (perhaps a threefold increase from the present, according to present projections). Human population growth and its need for expanded cultivation will induce a great deal of stress among the nondomesticated species. A new distribution of biomass among the species, better fitted to the dominance of man, is expected to come into being.

How much should be invested, then, to preserve an endangered species? How much risk is acceptable? The present answer seems to lie with the amount of human attention devoted to the respective species. If a species has no population of human appreciators, it will not be missed. The amount that can be invested in preservation depends upon the constituency of supporters that can be generated through the use of communications--published reports, letters, lectures, mass media, etc.

The cancer issue has different properties (Figure 4). A succession of furores in the media regarding food additives, water pollutants, contraceptives, and cosmetics refer to a list of specific chemicals, growing in number every month, held responsible for the

Figure 4



Source: Cancer and Chemicals. Chemical and Engineering News 56 (1/30/78) p.35

appearance of cancer in animals when administered in abnormal concentrations ("Cancer and Chemicals," 1978; Searle, 1976). Such cancers normally appear in humans after delays of decades, so the loss in longevity is low. Often, a small enhanced overall risk arises from the pursuit of alternatives--such as consuming sugar instead of saccharine (Cohen, 1978). The Science symposium "Medical Research: Statistics and Ethics" (Birnbaum Medical Symposium, 1978) hints strongly that human well-being (quality of life) at the level of the individual and group should be optimized when scientists intervene, hopefully also by the professions and the public decision-makers when they act. This criterion is remarkably similar to that of human experience introduced on the basis of ecological arguments earlier.

Ecology of Games

The reduction of risk, as considered to this point, has appeared achievable through (a) the free flow of information, (b) recording the events involving injuries and fatalities, even occasions where accidents were narrowly avoided, (c) estimations of the frequencies of incidents so that safe places and procedures can be distinguished from the dangerous, and (d) careful calculation of the alternative paths of action. An open, cooperative, and well-informed society could not only minimize fatalities and injuries, it could also compensate the losers that remain among the living. Huge insurance organizations have been built up to expedite the transfer of compensation, and the civil courts are very much involved. However, these prospects leave out of account the consequences of competition.

At each level in the ecosystem--whether gene, cell, organism, or organization--the living entity must compete as well as cooperate. Each is playing a game against Nature, which includes identifiable actors at its own level in its lifespace, as well as in the environment overall. If crucial information about an investment should be released, others could preempt the returns, and the investor would be worse off than before. Thus, unrestricted information transmission can add to risk as well as contribute to its reduction. Therefore, information becomes compartmented into classifications like top secret, confidential, private, trivial, potentially useful, and crucial. An internalization of the games being played, and the strategies available, determines how the information is to be classified.

At equilibrium the games being played are close to "zero sum"--one entity's loss is another's gain. When a living system is under stress many of the games will be negative sum. Then populations shrink, more species disappear, and overall biomass is reduced. Intense competition will restrict information flow. Conditions are quite punishing, but individuals, groups, communities, and organizations learn how to cope. That represents one way of describing the wild state of nature after human society preempts resources for itself and its domesticated species.

On the other hand, the increasing tendency toward risk aversion among humans causes them to select out positive sum games. Information is collected to discover such opportunities. Whenever the gains from a win-win type game are obtained quite consistently, there will be accumulation (growth in size of individual numbers in a population, extension of range, more built habitat, a piling up of recorded experience, etc.). The surplus from positive sum games provides the potential for elaborating structure in the community, enhancing its capacity to survive natural hazards and losses from conflicts with other communities.

We then see a society, or a complex (conglomerate or multinational) organization--made up of many communities--is reshuffled through differential growth while avoiding risks presented to it by the environment. Thus, it can evolve still higher levels of life capable of processing still more information. These still more complex organizations are acquiring the capacity to intervene at all lower levels. The net result is to manage the conditions so as to reduce risks in the wilderness as well. The phenomena are well known to foresters and wildlife biologists.

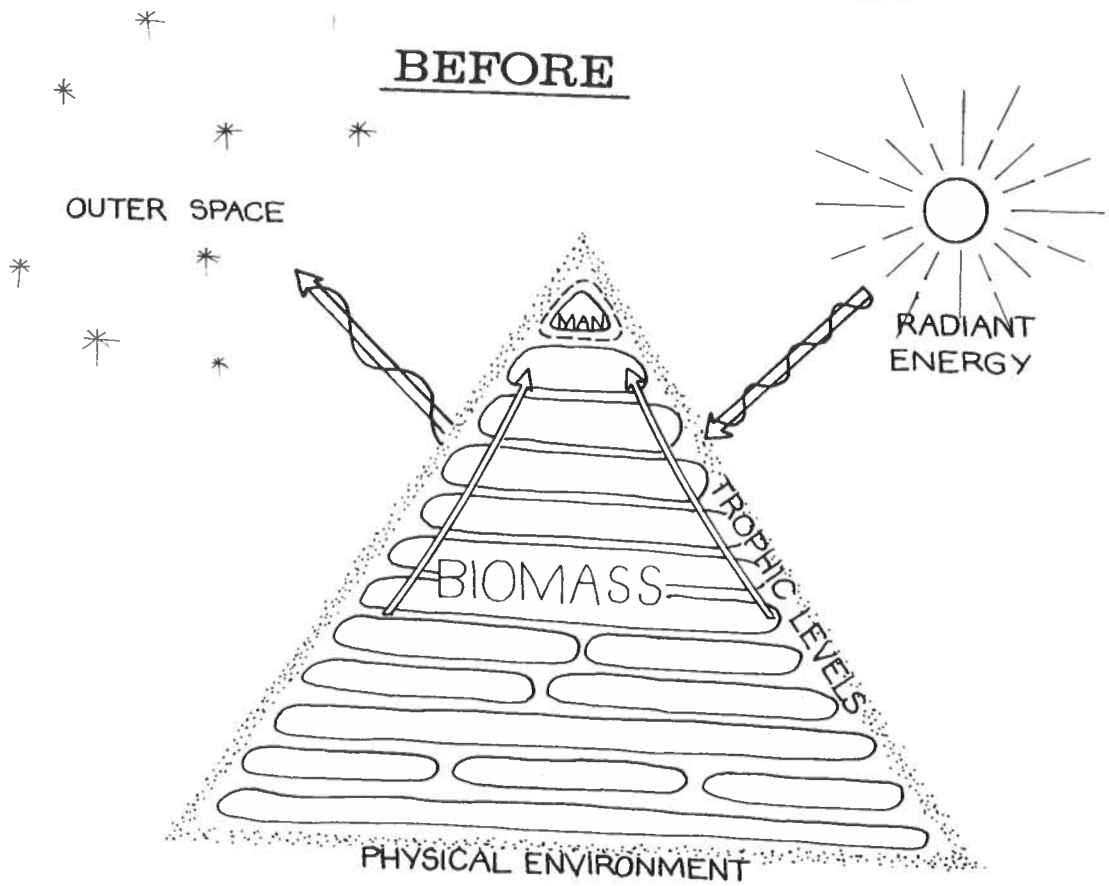
A partially managed nature maintained outside a much more carefully managed human habitat seems to be the direction toward which the biosphere is moving. The wild portion need not shrink at all, whether measured in biomass or diversity. If we look around us at the actions of government for protecting wildernesses, wild rivers, rain forests, and game preserves, we see risk aversion based upon human predilections being extended to the ecosystem as a whole.

The overall direction this multilevel living system is moving remains an enigma. Expanding risk assessment to multiple levels, as now recommended to planners involved with environmental impacts, imposes a special bias upon evolution (Figure 5).

The current biases are best identified by analyzing the structure and use of human communications. At present, and probably for a long time into the future, the bias is toward prevention of involuntary risk and (with some success) of newsworthy catastrophes and (so far with little hope) of cancer. A large share of the resources used for safeguarding people, endangered species, communities, and habitat will be dedicated to the minimization of the large loss

Figure 5

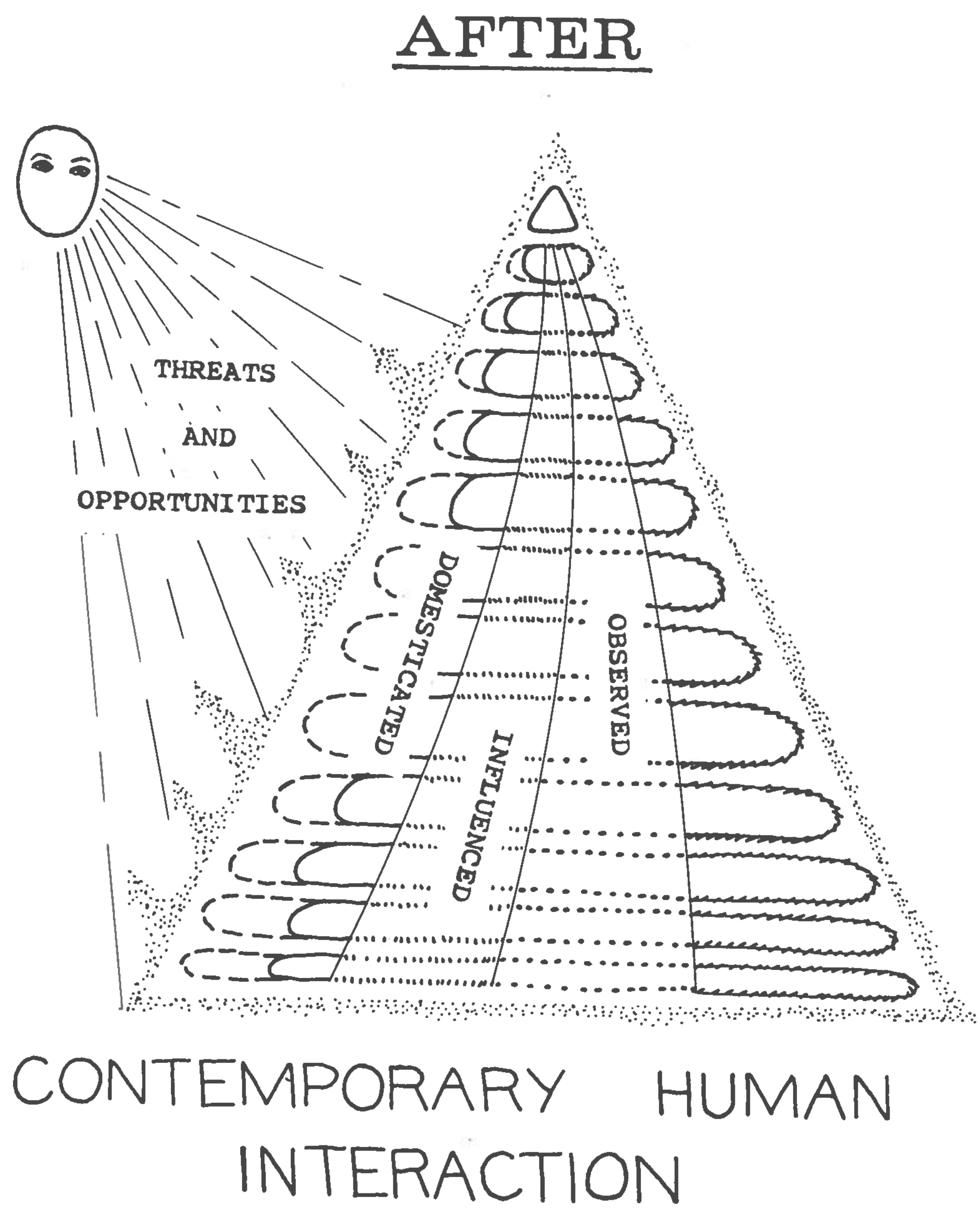
FUTURE OF THE ECOSYSTEM



FORCES GENERATING EVOLUTION AND DEVELOPMENT BEFORE THIS DECADE

Figure 5 (continued)

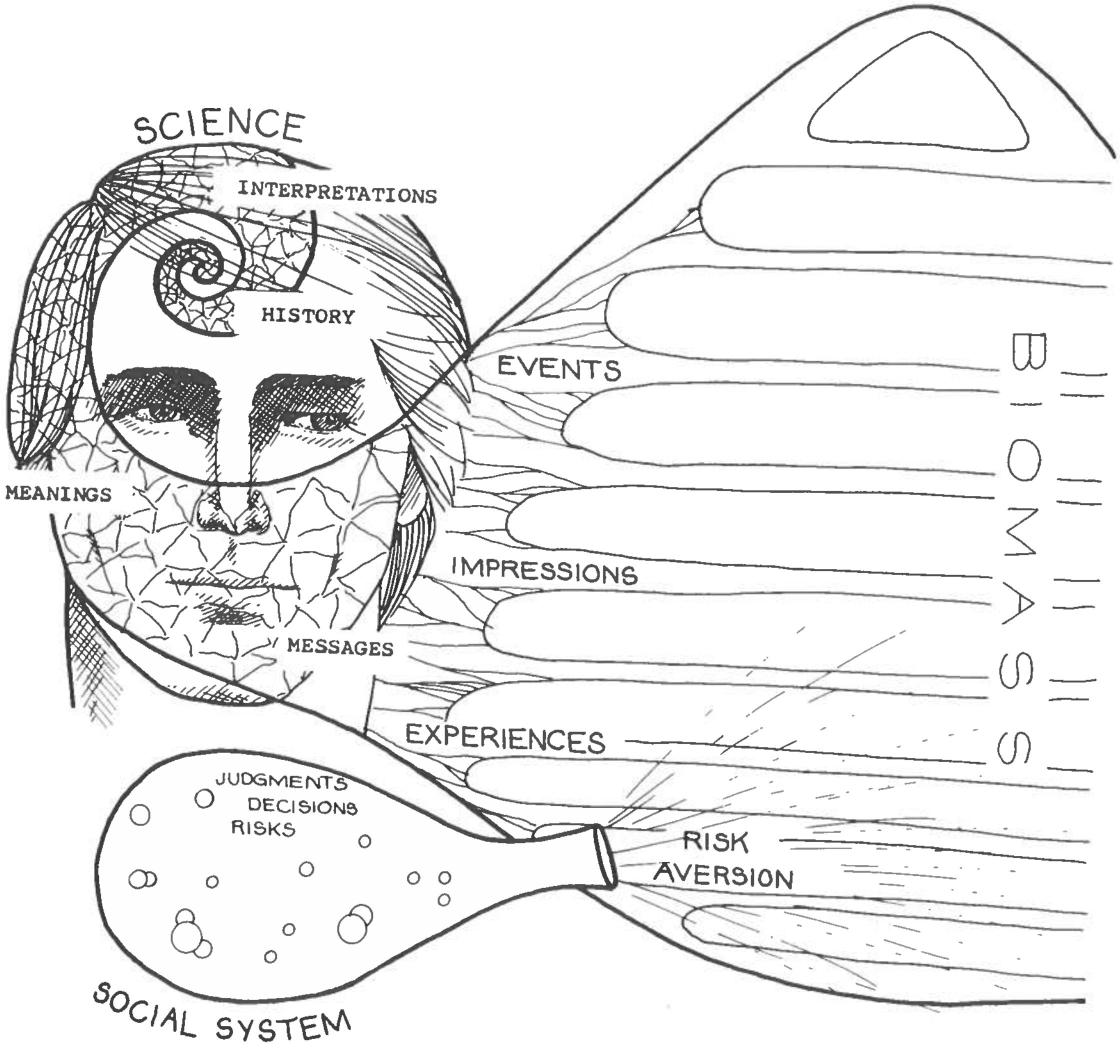
FUTURE OF THE ECOSYSTEM



events and other dreaded outcomes, apparently at the expense of day-to-day safety and the effort to postpone cataclysms. These peculiarities of human communication are solidifying into governmental regulations, corporate procedures, and societal standards, as well as cemented into law; they are also diffusing outward from the most developed countries into the less developed, so they will become global within decades.

If there exists a better rationale for intervention, one that is founded in the ecological sciences or in human philosophy, it should be enunciated quite soon. Ad hoc unformulated viewpoints are becoming deeply imbedded in our civilization. Moreover, it should take a form that acts directly upon the choice of content for the communication channels of all levels of sophistication. The scratches on human minds made by words and images determine the changes in expectations for survival (Figure 6).

Figure 6



FUTURE CULTURAL DETERMINANTS
FOR THE SURVIVAL OF TAXA:
THE COMMUNICATIONS CONNECTION

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