

Why Are There So Many of Us?

Description and Diagnosis of a Planetary Ecopathological Process

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Man is an apparition.

Eliot Porter, April 5, 1989
Tesuque, New Mexico

STATEMENT OF THE PROBLEM

The most stunning feature of the human population in the twentieth century is its rapid, unrestrained growth. Yet this phenomenon is not new. Several spurts in human population growth have occurred. One began with the end of the Paleolithic and the beginning of the agricultural revolution; another occurred at the beginning of the Industrial Revolution (Deevey, 1960; Hassan, 1981). As of 1990, more humans have been added to the total world population in the past forty years than in the previous three million years (Keyfitz, 1989). Between 7 and 8% of all human beings ever born are alive today (Weeks, 1989). Until recently, the rate of growth of the human population has been increasing, which means that it even exceeds exponential growth (Demeny, 1986; Bartlett, 1978). While the current rate of growth has slowed slightly, it remains exponential at approximately 1.7% per year with a population doubling time of about 40 years. There is wide disagreement about the prospects for future growth of the human population and whether, as well as under what circumstances and when, it will stop growing.

Accompanying this rapid population growth has been the increasing pace of human destruction of the global ecosystem. Small scale human assaults on the environment had little or no lasting impact during the early Pleistocene, although local and regional impacts began to be seen in the late Pleistocene and Neolithic (Martin, 1980; Angel, 1975; Darby, 1956). Beginning with the Industrial Age, large portions of previously intact ecosystems that had previously experienced little or no human perturbation have been destroyed. As the 20th century draws to a close, human activities are seriously and perhaps irreversibly disrupting features of the global ecosystem that are necessary to the preservation of human species and other life forms. Global atmospheric carbon dioxide levels, for example, have increased 25% during the last century (Mooney, 1988). Three of the warmest years in the past 100 years occurred in the 1980's (Schneider, 1989). Severe seasonal reductions in the ozone layers over Antarctica, and perhaps even the Arctic, are matters of great concern to atmospheric scientists (Graedel & Crutzen, 1989). Photochemical smog has become a permanent problem in most of the major cities of the world, and "megacities" are beginning to contain most of the earth's inhabitants (Dogon & Kasarda, 1988). Enormous areas of the world's rainforests are being burned each year, and these conflagrations result in layers of smoke haze that cover tens of thousands of square kilometers. Innumerable species have become extinct as the direct result of human activity, and the rate of extinctions is increasing (Ziswiler, 1967; Hoage, 1985; Wilson, 1988). Wilson (1990) estimates that, at the present rate of ecosystem destruction, as many as 25% of all living species will

become extinct within the next fifty years. Today, one oil tanker captain can wipe out a whole ecosystem; incidents of this kind fill daily headlines. At the same time, there is growing consciousness of our global ecosystem and the need to preserve it (SCEP, 1970; Boulding, 1973; Ehrlich et al, 1977; Lovelock, 1979; Russell, 1983; Myers, 1984; Rambler et al, 1989; Sahtouris, 1989; Daly & Cobb, 1989).

The human population has often been compared to some kind of planetary disease (Gregg, 1955; Easley, 1961; Russell, 1983; Odum, 1989). Geologist Peter Flawn, speaking to students at Northwestern University in 1970, said that the earth's crust has a skin disease, a case of microbes infecting its crust, and that sickness is man (Flawn, 1970). Diagrammatic views of human settlements do have a certain similarity to some kinds of pathological lesions, including various kinds of dermatitis. Flawn's and other observations stimulate a search for other pathologic models. Lewis Mumford's (1961) book, *The City in History*, is suffused with references to large cities as pathologic processes. Geddes (1915), included a scheme of cities that included "pathopolis." Because spectacular growth and invasiveness are outstanding characteristics of the human population, the similarity of the human species to a cancerous process comes readily to mind, especially to a physician. A schematic view of the growth of London from 1800 to 1955 looks like nothing so much as an expanding, invasive, metastatic, malignant tumor (Johnson, 1972, Figure 1).

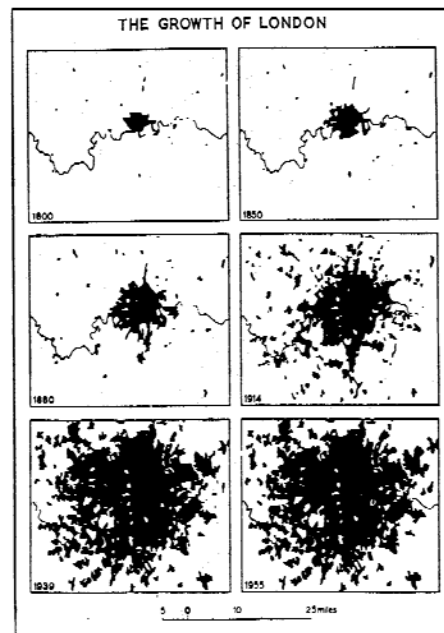


FIGURE 1. The growth of London, 1800-1955 (Source: Johnson,1972).

A nearly identical pattern is seen in the growth of Baltimore from 1800 to 1950 (Gist & Fava, 1964, Figure 2;Hoover, 1948).

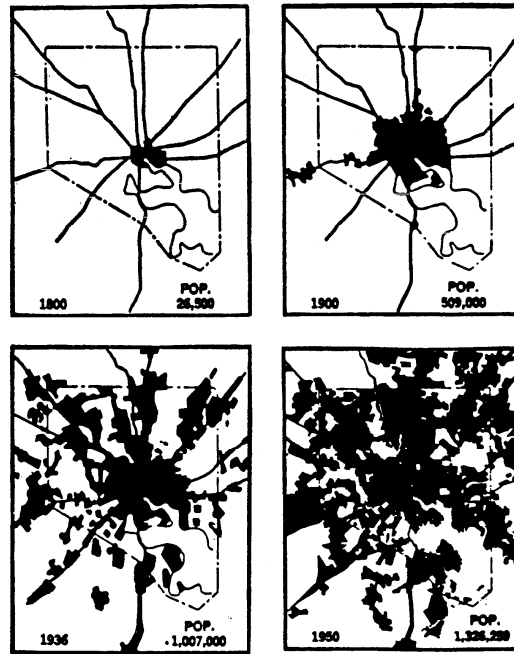


FIGURE 2. The growth of Baltimore, 1800-1950 (*Source: Gist & Fava, 1964*).

Characteristics of Human Populations and Communities

Humans can be studied in the same manner that we study other species and organisms. Within certain limits, humans appear to share the same characteristics and be subject to the same physical and biological laws as other species. Survival curves of humans, for example, can be compared to species as different as black-tailed deer (Taber & Dasman, 1957), fruit flies, and oysters (Deevey, 1960). Population pyramids can reflect the relative age distributions of either human or other populations (Odum, 1971). There are, in fact, several kinds of age distribution among human societies. One of the most common found around the globe at this time is that of a young and rapidly reproducing population with up to 50% of the population under the reproductive age (Hern, 1977; 1988). Growth curves in the populations of various species tend to level off (Odum, 1971), but some phases of population growth may be extremely rapid. The human species has shown the latter pattern since its origin with a markedly increased rate of growth in recent centuries (Hassan, 1981, Figure 3).

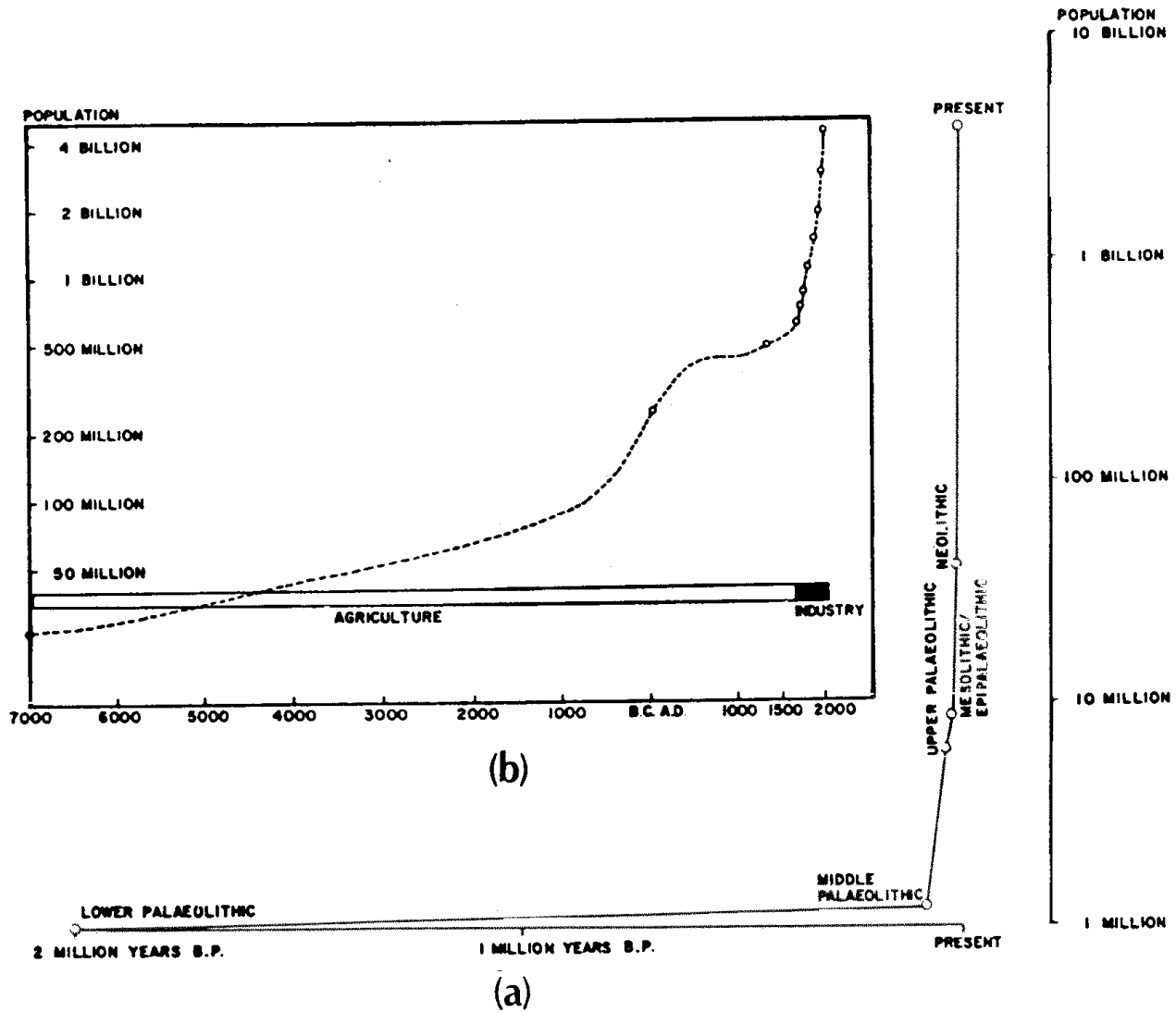


FIGURE 3. a) The growth of the human population over the past two million years. (Source: Hassan, 1980) b) Pattern of population growth over the last 9,000 years. Shown clearly are the remarkable acceleration in population growth rate and the dramatic increase in world population size over the last few centuries (data from Hassan, 1978; Thomlinson 1965)

Studies from population biology repeatedly show that species whose populations are increasing rapidly are subject to severe fluctuations in population size and viability as found in, for example, Kaibab Plateau deer (Rasmussen, 1941; Leopold, 1943; Figure 4), adult thrips (Davidson & Andrewartha, 1948), and *cardiaspina albitextura* feeding on eucalyptus trees (Clark, 1964). Population crashes are often described in rapidly growing populations that exceed carrying capacities of their ecosystems or local food supplies. Margalef (1968) illustrates this principle with his diagram of a negative feedback loop (Figure 5). Some population crashes may result in no recovery of the original population, or it may fluctuate around an average that appears to be set by the carrying capacity of a given ecosystem (Boughey, 1973, Figure 6). Predator-prey relationships can produce population size fluctuations

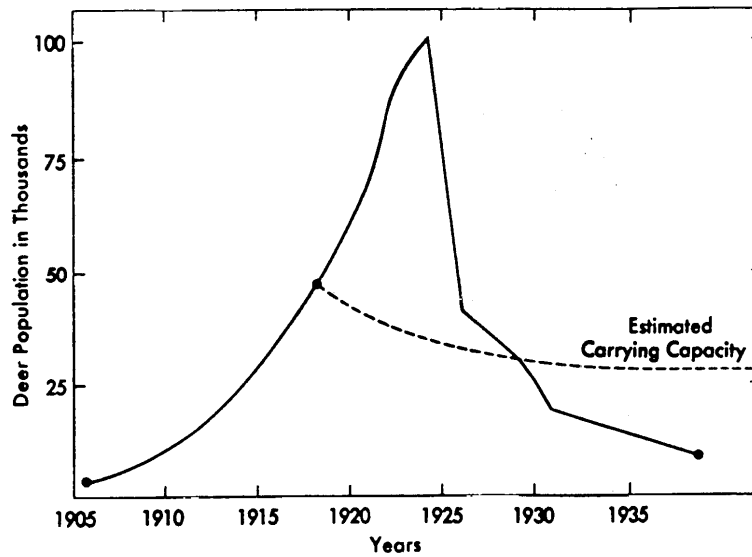


FIGURE 4. Population growth and crash of Kaibab Plateau deer (Source: Boughey, 1973)

in a series of linked oscillations, as in the classic case of the snowshoe hare and lynx populations (Figure 7; MacLulich, 1937). A single predator-prey relationship leads to sharp

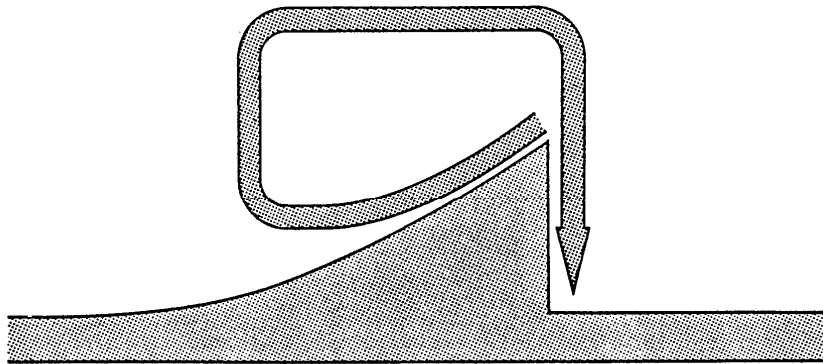


FIGURE 5. Negative feedback loop. (Source: Margalef, 1968)

oscillations in population sizes, but more complex predator-prey relationships lead to damped oscillations that tend to be uniform around an average over time (Figure 8; Wilson & Bossert, 1971).

An important concept in population biology is that populations tend to maintain themselves in a series of damped oscillations. Digression from this pattern results in severe instability and even extinction.

Part of the instability and vulnerability to extinction appears to be related to stresses that develop under conditions of high population density and severe crowding as shown by the well-known experiments of John Calhoun (1962) and John Christian (1980). Crowding leads to

social and biological pathology that results in high mortality and diminished group survivability (Cassel, 1971; Aaby et al, 1983).

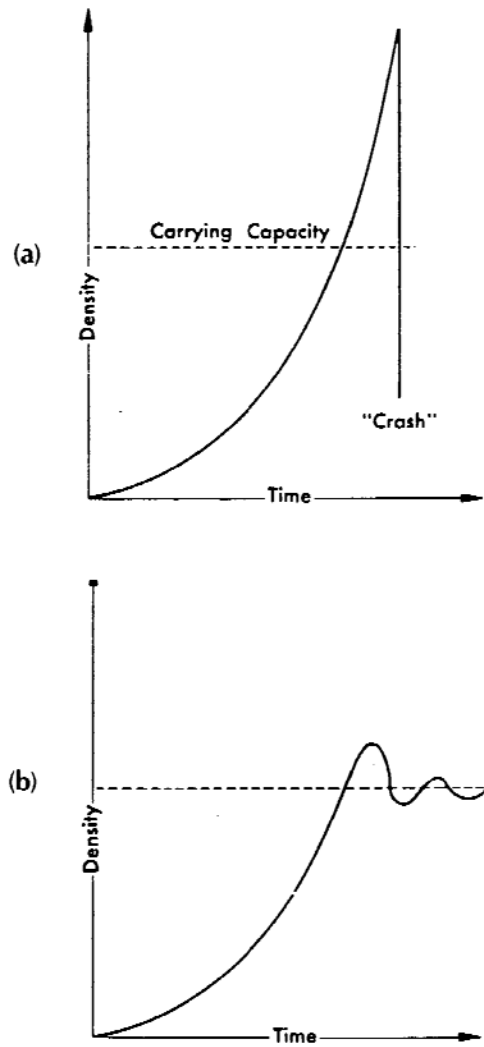


FIGURE 6. Population increase, overshoot, crash, or return to carrying capacity level with damped oscillations (*Source: Boughey, 1973*). a) A theoretical example of population increase that has overshoot the carrying capacity, with a resultant crash. B) A theoretical example of population increase having a curve of J form that has slightly overshoot and is oscillating about the carrying-capacity level.

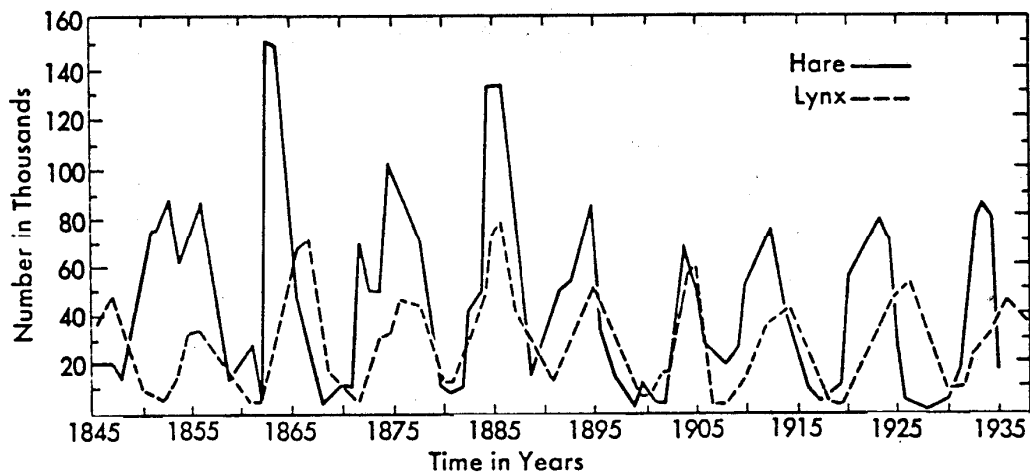


FIGURE 7. Prey-predator relationship of lynx and snowshoe hare, showing linked oscillations of population levels (Source: Boughey, 1973).

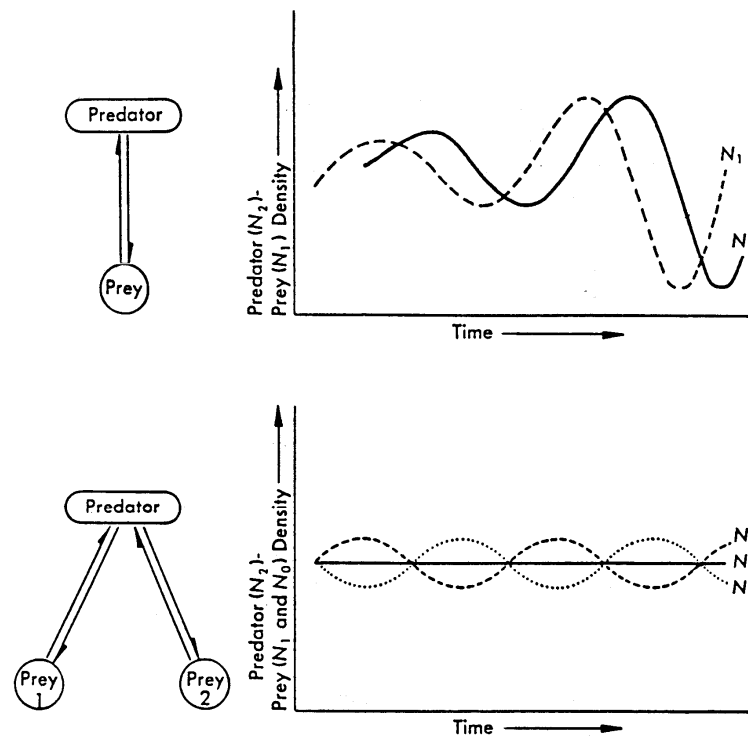


FIGURE 8. Model of single and multiple prey-predator relationships (Source: Boughey, 1973).

An important characteristic of historic human population has been the ability to circumvent these stresses through group fission, emigration, and colonization of unexploited new territories. As a result, thousands of years of intercontinental and intracontinental migration have resulted in the permanent colonization of virtually every part of the terrestrial global ecosystem by humans and the development of colossal and rapidly growing human settlements that envelop and engulf the adjacent ecosystems. Surrounding colonies, or suburbs, become indistinguishable parts of the urban sprawl.

While migration and colonization strategies were available during the last 10,000 years of human history, when rapid population growth began occurring, they are no longer available. Population migration and concentration is in the direction of large cities where the stresses of high density develop new urgency and intensity for individuals.

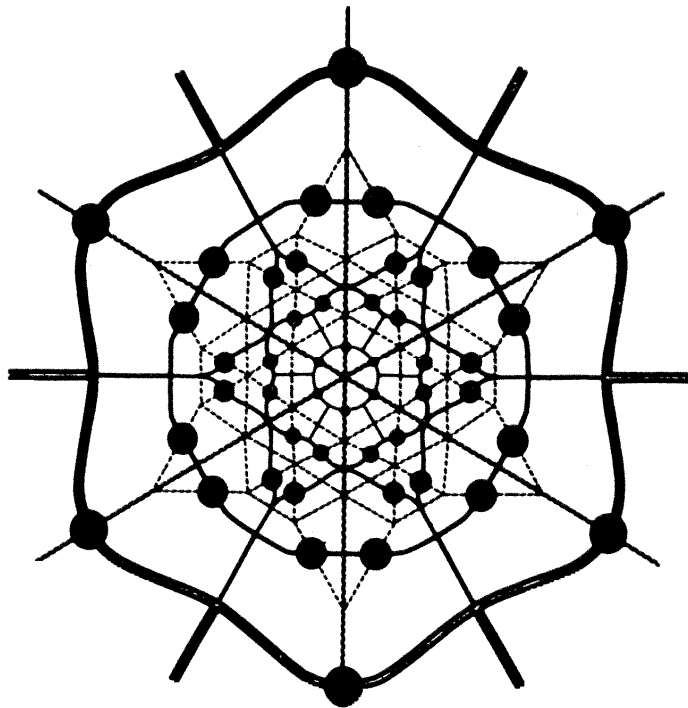
Human populations have responded to population pressures with a variety of strategies other than migration, including predation and agricultural intensification (Abernethy, 1979; Sahlins, 1961; Cohen, 1977).

Human Communities

A striking feature of human communities is that they are becoming indistinguishable in appearance. Ancient human communities frequently exhibited unique architecture and residence

patterns that were characteristic and specific to a particular culture or area (Jordan & Rowntree, 1986). The boundaries of cities were carefully delimited by having city walls. Cities were sometimes located for defensive reasons at sites where the physical topography either required this practice or provided the means by which it was accomplished, as in the case of Italian hilltowns (Carver, 1979). In more recent times, the boundaries of communities everywhere have become indistinct while they are becoming more extensive.

Urban planners and students of human communities have for many years referred to their subjects in aggregate terms. Gruen's (1973) depiction of the "urban organism" is shown in Figure 9. Lewis Mumford (1961) wrote that ancient cities could be dated in their growth almost like tree-rings by the steady expansion of their outer wall. Now, with the phenomenon of "conurbation," as it was called by Patrick Geddes (1915), the new "... urban tissue was less differentiated than the old. It presented an impoverished institutional life; it showed fewer signs of social nucleation; and it tended to increase in size, block by block, avenue by avenue, 'development' by 'development', without any individuality of form and, most remarkable of all, without any quantitative limits" (Mumford, 1961).



In discussing ecosystem changes, including atmospheric and vegetational changes, brought by large urban settlements, Wolman (1965) refers to the "metabolism of the city." The phenomenon of the "urban heat island" is well known and may contribute significantly to the process of global warming (Jordan & Rowntree, 1986).

Cities have everywhere exhibited a process of "de-differentiation" at the community level, becoming superorganisms without form, invading and destroying the surrounding natural environment, and expanding at a rapid rate. Figure 10, from Gruen's (1973) *Centers for the Urban Environment*, gives a phantasmagoric illustration of this idea. In the view of Ian McHarg

(1969), the modern city is an ecological desert, hostile to human and other forms of life, where nothing grows.

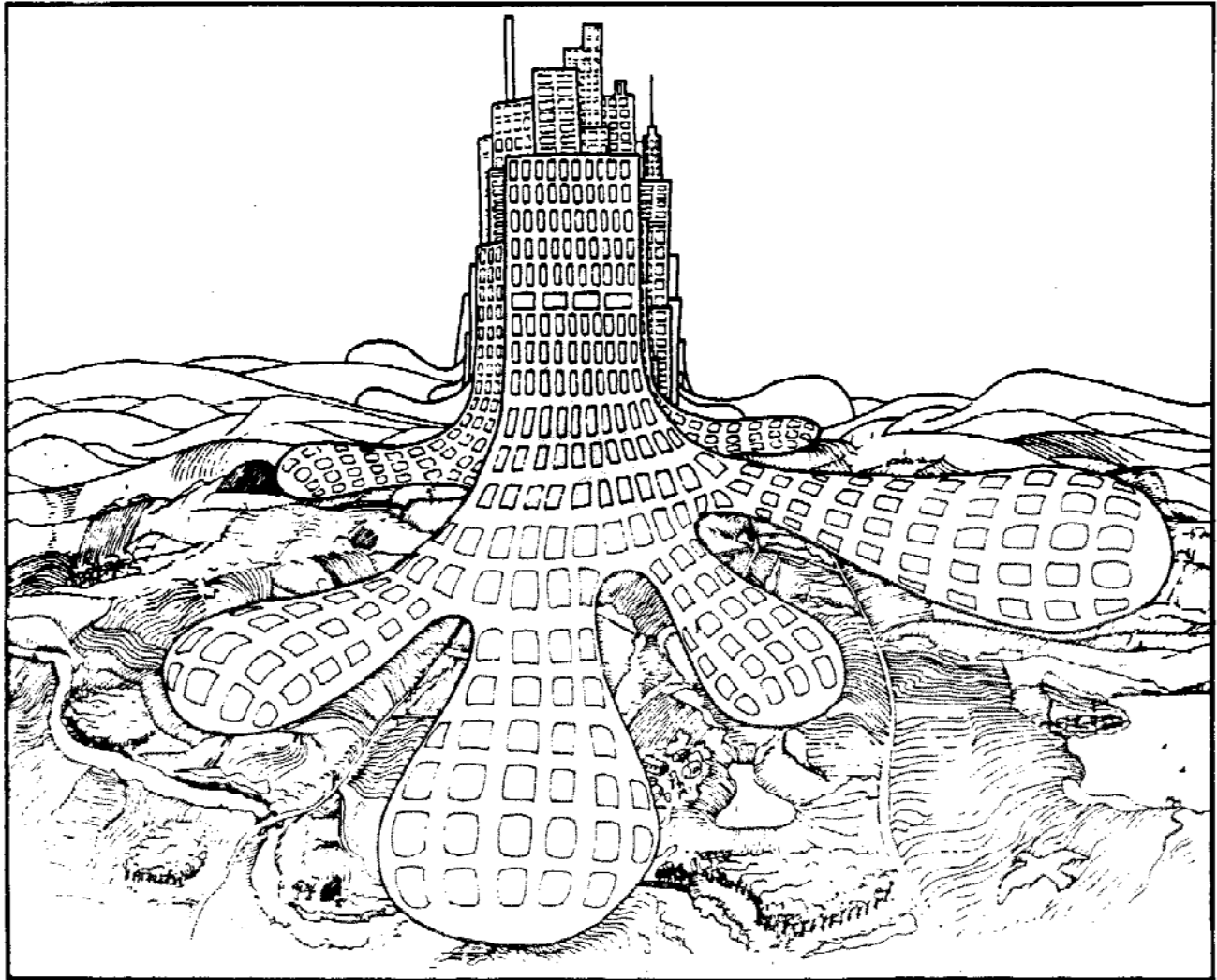


FIGURE 10. “The city devours the countryside”. (Source: Gruen, 1973).

Models of Pathologic Processes

If we perceive the human species as one that is destructive to others and even to the ecosystems in which we live, and if we begin to look for analogies or comparisons with other organisms or pathologic processes to help us understand the process we are both witnessing and causing to happen, we must devise a hypothesis that explains reality and predicts events. That is the purpose of a hypothesis. Our hypothesis must be one that, within reasonable limits, permits us to explain a set of events and observations that have hitherto appeared to be unrelated or to be related in a way that is not yet clear to us. In this case, it must be a hypothesis that includes aspects of human behavior and biology as well as anthropogenic changes in the ecosystem (Cassel, 1964). We must be prepared to explore any possibility.

Linear mathematical models have important limitations in describing large systems for which we have partial or unreliable information, and they are especially deficient in describing biological systems. For example, the General Circulation Model (GCM) (Schneider, 1989) is a highly sophisticated mathematical model which describes the global climate changes resulting from the accumulation of greenhouse gases, but such models do not explain the wide variety of biologic or other geomorphologic phenomena that accompany or result from human activities (Sagan, et al, 1981). The GCM may be explanatory for a few phenomena such as climatologic changes, but not most kinds of global change, and it does not help us with causal inference to determine why global ecological change is happening except in a very limited sense.

The difficulty of using models to compare humans to other species or processes is that humans have culture, which permits the transmission of knowledge from one generation to others, sometimes over spans of thousands of years and thousands of generations. Human culture gives us the capacity to adapt to inhospitable circumstances and environments in ways not available to other species. We are not, in fact, subject to some of the same biological limits and constraints that limit the actions and growth of other species.

Comparing the human species to some pathologic process is fraught with hazard. If we make the comparison of the human population to a pathologic process as did Professor Flawn, we take the risk that it will be inappropriate because of differences in scale as well as differences in process. How can one compare the human species to dermatitis? Dermatitis can be caused by a variety of factors including microbes (bacteria or fungi), autoimmune or allergic processes, toxic substances or other physical agents, or by psychogenic disturbances. Dermatitis does not often become invasive and it usually does not threaten its host. The consequences of human activities neither fit into such neat categories nor are they that benign. If human activities appear to be pathological for the global ecosystem, we must find a more comprehensive model. Among the possibilities are the pathologic categories of parasitism, neoplasia or disturbances in growth, infectious disease and inflammatory processes, and autoimmune disorders (Perez-Tamayo, 1961).

In reviewing these alternatives, the model including "disturbances in growth" is immediately appealing since growth is the single most dramatic and obvious characteristic of the human population. Growth of the global human population can only be characterized at this time as unregulated and increasing rapidly. It is slower and moderately regulated in some localities and even in some regions, but it is nonetheless inexorable in the global perspective. In the early Pleistocene, the annual human population growth rate probably did not exceed 0.001% including minor and temporary local fluctuations (Hassan, 1981). The human population doubled every 100,000 years or so. In the Neolithic, population growth increased to a rate of 0.1% per year, doubling every 700 years (Saucier, 1972). By A.D. 0, the total human population was approximately 250,000,000, but it doubled to 500 million by about 1650. The Black Death in the 14th century removed one-third of the human population, resulting in a temporary reduction in the rate of growth, but the population then doubled again to 1.1 billion by 1850,

only 200 years later. World population reached 2 billion some time in the early 1930's, and it reached 2.5 billion in 1950. The human population is now doubling every 35 to 40 years. We are adding between 90 and 100 million people to the world's population each year. Depicting this extremely rapid growth on an arithmetic scale that includes the Pleistocene or even the past few thousand years shows a growth curve that is similar to those seen in other populations just before they collapse. Yet humans have shown an extraordinary resistance to forces that cause other species to collapse.

Rapid, uncontrolled growth is a principal characteristic of one kind of neoplasm (new growth), that of a malignant neoplasm. Malignant neoplasms display four main characteristics:

- Rapid, uncontrolled growth
- Invasion and destruction of adjacent normal tissues
- De-differentiation
- Metastasis to different sites (Anderson, 1961; Perez-Tamayo, 1961)

Cancers also show what cancer biologists call progression, or an evolution toward greater malignancy, with less differentiation of cells, faster growth, and more metastatically aggressive cells (David Prescott, personal communication; Ruddon, 1987).

MALIGNANT CHARACTERISTICS OF THE HUMAN SPECIES

We may now examine those characteristics of the human species as a whole that suggest the comparison with a malignant process. Recognition of a malignancy depends on a "group of morphologic changes" as well as behaviors. A malignant neoplasm is defined as "... an uncontrolled new growth of tissue composed of components which have the power of growth and multiplication relatively free from the usual restraints" (Anderson, 1961).

Rapid, Uncontrolled Growth

There is no evidence that overall growth of the human species is limited at this time or has been for at least 10,000 years. There is no reliable indication that growth of the global human population will be voluntarily limited in the foreseeable future. This is not to say that humans do not have the capacity to regulate their population growth. On the contrary, the efforts of humans to control their fertility is widespread, legendary, and heavily documented (Devereux, 1955; Birdsell, 1957, 1968; Himes, 1970; Nag, 1962; Polgar, 1968; Dumond, 1975; Tinker et al, 1976; Hern, 1976). Humans have regulated their fertility in early human existence and even among contemporary preindustrial populations. Much of our modern population growth is not the result of better medical care but disruptions of the ancient controls on fertility and natality that have previously kept population growth at lower rates. Recent research among some South American Indian groups has shown extremely high fertility which can be related to disruption of traditional checks on fertility and natality (Hern, 1988; Hem, 1990).

In spite of efforts to control fertility, the global human population has not recently succeeded as a species in doing so. There are numerous instances of powerful forces that block attempts to control human fertility and even encourage fertility. These range from heads of state and heads of religious hierarchies to private interest groups. The current President of the United States, George Bush, judged that he could gain votes and enhance his prospects for being elected by advocating the imprisonment of doctors who perform abortions (Boyd, 1988). He received no effective criticism and paid no political price for this position. The current Pope is famous for going to places where members of the rapidly growing local population have stripped the original vegetation from the landscape in a desperate effort to feed themselves and, upon arriving, exhorting them to reproduce themselves as much as possible. Pronatalist forces are, for the most part, in control of human institutions. A recent and dramatic local reversal of this tendency was the overthrow of Ceaucescu in Rumania. The first act of the new revolutionary government was to lift Ceaucescu's ban on abortion and contraception.

On the other hand, the U.S. government, which has a powerful influence on world population policies and programs, announced at the 1984 International Conference on Population at Mexico City that population growth is "neutral," that localized population growth crises are evidence of "too much government control and planning;" population growth should be slowed by "natural mechanisms" that will follow from "development" (Menken, 1986). The current United States government has withdrawn support for the U.N. Population Fund.

One of the main characteristics of a cancerous growth is that it resists regulation. A cancer cell is a cell that reproduces without limit (Prescott & Flexer, 1986). The regulatory mechanisms that determine the rate of cellular multiplication and increase in total mass are disturbed to the point that growth is not controlled. Regulatory mechanisms may be present, but they are not present in sufficient quantities to be effective, and they are ultimately destroyed by the unregulated tissue (Anderson, 1961).

The fact that some humans limit their fertility effectively, do not reproduce, or advocate the widespread availability of methods of fertility limitation does not change the corollary fact that the human species as a whole does not operate at this time under any constraint on the growth of its numbers.

Invasion and Destruction of Adjacent Normal Tissues

We have from the beginning of recorded history seen examples of human destruction of the global ecosystems beginning with deforestation of the Mediterranean (Darby, 1956; Angel, 1975; Jordan & Rowntree, 1986). The forests of the cedars of Lebanon were destroyed forever to build the ships of the Phoenicians and the Temple of Solomon. Examples of local ecosystem destruction are innumerable.

Cancers spread by two means: extensive invasion and by metastasis, or distant colonization. Human communities, once established, tend to invade and destroy all adjacent

ecosystems without limits. Because of prior limitations of technology and sheer population size, and because of cultural traditions that respected natural ecosystems, this was not always so, but it appears now to be occurring routinely. There is no ecosystem on the planet that is not already

destroyed, invaded, or immediately threatened in some manner by the human species. In fact, the global ecosystem is itself under considerable stress from human activities, and this process is expected to accelerate (Gentry, 1980; Sagan, 1981; Fyfe, 1981; Gomez-Pampa, et al, 1973; Moriarty, 1988; SCEP, 1970; Goudie, 1982; Hafele, 1980; Mooney, 1988; Repetto, 1989).

De-differentiation

To the pathologist or oncologist, the term "de-differentiation" has a variety of meanings, but it principally refers to individual cell type. A normal cell has a characteristic appearance that identifies the kind of tissue and even the organ from which it derives. Heart tissue has the appearance of muscular tissue and it can be identified as being from the heart. Columnar cells that line the bowel or cervix have typical appearances. Cancer cells tend to lose this differentiated appearance. The pathologist may be able to determine that a certain cancer cell is from adenomatous tissue but may not be able to tell whether it was originally from the breast, bowel, or parotid gland, or that a squamous cell cancer originated in the lung or somewhere else.

Sometimes, cancer cells just look like cancer cells but their general origin is not apparent. The less a cell appears to be from a specific kind of tissue, the more likely it is to be malignant; the more unidentifiable it is, the more likely it is to be part of a highly malignant and aggressive tumor.

A mass of cancer tissue can also appear to be undifferentiated in the sense that no specific structure is visible. There is no way to determine the cell origin either from the appearance of individual cells or from the gross appearance of the lesion. Sometimes, to be sure, particular malignancies have characteristic appearances, but even these have lost the original relationships among the cells and structures that give it a normal appearance and function.

On an individual basis, human beings are remarkably similar in anatomy, physiology, and appearance worldwide. There are minor intraspecific differences that include skin color, stature, facial configuration, and specific local adaptations to heat or cold, or even adaptations to specific disease problems such as sickle-cell trait that protects against falciparum malaria, but the differences that are present with other species adapted to different ecosystems are absent. Cultural adaptations, instead of physical adaptations, bridge the gap between the !Kung Bushman in the Kalahari Desert and his brother Nunamiut Eskimo hunting seal in the frozen Arctic. They are the same species even if they cannot understand each others' language, behavior, diet, or manner of spouse selection. Human beings are "anaplastic" in the sense that they are physically not highly differentiated among themselves, and increasing contact among

all groups accelerates the loss of both physical and cultural differences among individual members of the species.

In a broader sense, however, the critical factor in human "anaplasia" is found in the capacity of culture to eliminate the importance of differences in physical adaptations or even specialized subcultural adaptations that were previously necessary for survival in local ecosystems (Frisancho, 1981). The Eskimo may now use a snowmobile instead of a dogsled or kayak to reach a hunting site on the other side of the bay. Western technological adaptations permit non-Eskimos to live on the North Slope of Alaska with reasonable comfort in a climate and setting only survivable previously by those steeped in a highly specialized culture highly adapted to that rigorous environment. I go to live with my Shipibo Indian friends in the upper Peruvian Amazon without having to know a thing about hunting *Arapaima gigas* with a harpoon or hunting collared peccary with a bow and arrow. My own cultural adaptations, which I take with me, and my ability to use language and medical skills to exchange types of assistance with the Shipibo, permit me to live with them comfortably for long periods of time. Put me in the jungle by my self without equipment and I would probably not last long. Conversely, my Shipibo friends would not last long in the Colorado winter without the local cultural adaptations that I could provide or teach them to use. Negotiated exchanges of specific cultural adaptations, which diminish differences in local adaptations, minimize human difficulties in surviving extremely different environments.

Because of their mobility and capacity for cultural adaptations, humans can exploit and survive in widely scattered and different ecosystems (Moran, 1982). In that respect, humans are different from most other vertebrate species that are highly adapted to narrow and specific ecological niches. Anthropologist Joseph Birdsell (1968) observed that man has "given up density for plasticity" (p. 248). Anthropologist William S. Laughlin (1968) noted that, upon finding a horse, a man can run it down in two or three days, then "decide whether to eat it, ride it, pull a load with it, wear it, or worship it" (p. 313). Humans are ecologically more versatile than any other vertebrate species.

De-differentiation at the community level

While the argument can be made that individual human beings are "de-differentiated" members of a single ubiquitous species, the expression of de-differentiation in human populations can be illustrated at another level of analysis, namely, the community level. A visitor from space might see, not individual human beings, but lesions on the earth's landscape, some with interconnecting links. The lesions now glow in the dark. (See the *Scientific American* cover of September, 1989). A space observer watching the planet for the past three thousand years would see, first, a wide variety of these lesions with very discrete borders, layouts, and permanent structures with unique forms. The architecture of permanent structures would be specific, in many cases, to discrete locations on the globe. The Yanomama oval community house would be distinctly different from the Kayapo or Waorani longhouse and these different still from the architecture and residence patterns of the Dogon in West Africa and the conical trulli houses of

southern Italy (Carver, 1979). Now the international traveler finds rows of identically appearing cottages or apartment houses in Zagreb, Sao Paulo, Levittown, and Houston. The skylines of Chicago, Sao Paulo, Denver, and Tokyo are more similar than they are different. Appearances of human communities at the large scale level, particularly in urban centers, are quickly disappearing. In fact, scalar differences aside, the morphology of settlement patterns of large human communities are not only becoming indistinguishable from each other and undifferentiated in appearance, they are becoming indistinguishable from the morphology of malignant lesions found in nature.

Malignant tumors are characterized by highly irregular and invasive borders that are indistinct. Benign tumors tend to have distinct and even encapsulated borders and are not invasive. When images of malignant lesions are compared with images of human communities, especially modern urban conglomerates, and scalar/tonal differences are minimized or eliminated, as in Figures 11-15, the malignant lesions and human communities are highly similar, even indistinguishable, in their appearances. These two widely different phenomena have the same morphology. In function, each aggressively invades adjacent space and replaces the previous tissue or ecosystem with its own. As malignant neoplasms establish local metastases, so do cities develop satellite communities that ultimately become part of the larger process. Aerial photos, satellite images, or abstracted images of human communities and other corporate human activities over time anywhere on the planet illustrate this phenomenon (Figure 16). It is a study that should lend itself to the use of fractals as a research tool (La Breque, 1986/7).

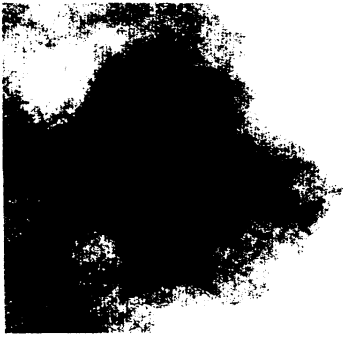


FIG. 11



FIG. 12



FIG. 13



FIG. 14

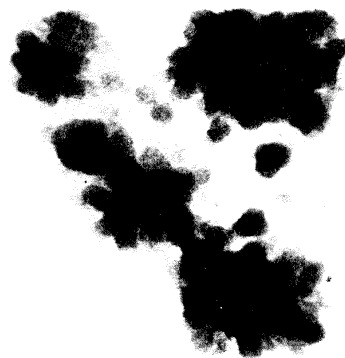
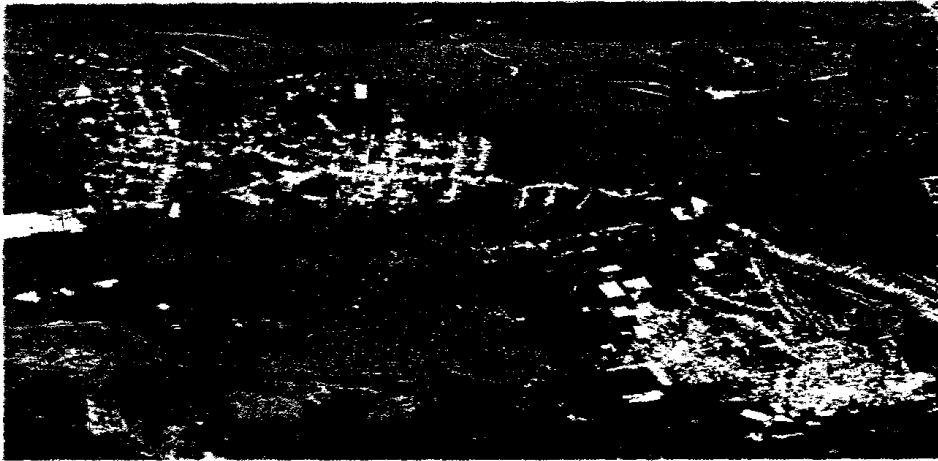


FIG. 15

FIGURES 11-15: Comparison of morphologic similarities between metastatic lesions and human communities.

a) pulmonary adenocarcinoma; b) metastatic malignant melanoma; c) Baltimore; d) metastatic malignant melanoma; e) five-city cluster, North Carolina



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FIGURE 16. A comparison between Landsat thematic mapper 1.55-1.75 μm data from 1984 and 1988 documents increases in tropical deforestation in the Amazon Basin, Mato Grosso, Brazil. Deforested areas appear lighter, while undisturbed areas of tropical forest appear darker. (Source: Instituto Nacional de Pesquisas Espaciais).

Odum (1989) notes that cities are highly heterotrophic, parasitic ecosystems since they consume much more energy than they produce. As the megacities of the late 20th and early 21st century develop, with numerous urban centers containing tens of millions of inhabitants, the world's large cities become concentrated heterotrophic systems drawing energy from distant parts of the planet and creating a quantum increase in entropy.

Metastasis

Metastasis, or dissemination to distant sites, is a primary feature of malignant neoplasms. By this means malignant neoplasms become established in different organ systems far from the tissue or organ of origin. It is the process by which cancer most quickly and lethally spreads to kill the host organism.

The corollary of metastasis in the human population is the establishment of new human colonies in sites distant from the origins of their members. The migratory abilities of human beings are astounding. Even more astounding is the ability of human beings to find a new ecosystem, identify the beneficial and harmful components of the system, and adapt their culture to meet the needs for survival in the new system. The Amazon rain forest, for example, is an exceedingly complex environment, but native Amazonians have successfully lived there for at least 10,000 years (Lathrap, 1970; Roosevelt, 1980; Posey, 1983). They were doing well until contacted by European explorers (Denevan, 1976; Myers, 1989; Hecht & Cockburn, 1989; Hern, 1990). Crosby (1988) has documented the expansion of European culture through colonies and the destruction that it brought to New World ecosystems. Along with these contacts came devastating epidemics and loss of up to 95% of indigenous populations (Dobyns, 1983) followed by rapid expansion of colonial populations. Even Malthus (1798) commented on the rapid growth of populations in the American colonies. The consequences of colonial expansion are similar in many ways to highly aggressive metastatic cancer.

Criteria for Diagnosis

Of the four characteristics of malignant tumors, pathologists generally require that a tumor display two in order to be categorized as malignant. Also, behavior of a tumor is more important than its histogenesis (Perez-Tamayo, 1961).

It is my hypothesis that the human population has all four characteristics of a malignant process, and that its behavior in at least three of the four categories is clearly malignant (Table 1.)

TABLE 1

Comparisons Between Malignant Tumors and Human Populations

Malignant Tumors	Human Species
Rapid, uncontrolled growth	Rapid, uncontrolled growth
Metastasis	Colonization, urbanization
De-differentiation	Adaptability through culture
Invasion & destruction of adjacent normal tissues	Ecological destruction by most human societies; now threatens global ecosystem
Grows in spite of host starvation until host dies	?

DESCRIPTION AND DIAGNOSIS

The human species is a rapacious, predatory, *omnicophagic* species engaged in a global pattern of converting all available plant, animal, organic, and inorganic matter into either human biomass or into adaptive adjuncts of human biomass. This is an *epiecopathological* process that is both immediately and ultimately *ecocidal*.

In this respect, the human species is an example of a malignant *ecotumor*, an uncontrolled proliferation of a single species that threatens the existence of other species in their habitats. A giant flock of starlings or blackbirds may be an example of a *benign ecotumor* that is obnoxious to humans, but it is unlikely to leave any lasting damage. An example of another malignant *ecotumor*, however, is the crown of thorns starfish species that is destroying the Great Barrier Reef in the South Pacific (Yonge, 1963). Yet another is the lamprey eel, which gained access to the Great Lakes via St. Lawrence Seaway and destroyed the native fish in the Great Lakes (Benard, 1989). Both are the result of disturbed regulatory mechanisms or anthropogenic disruptions within the ecosystem (Moriarty, 1988). In the case of the lamprey eel, humans have begun to reverse the ecological damage by the application of sophisticated technology.

DISCUSSION

A highly malignant form of cancer resists all efforts at effective regulation until the host has died. Cancerous tumors continue to grow even in the face of starvation of the host (Ruddon, 1987).

In the case of the human species, this hypothesis predicts that the global ecosystem, the supporting substrate, would have to be destroyed before the malignancy is halted, if, indeed, it ever halts. A peculiar property of the human species is that it is ingenious in its cultural adaptations to difficult survival problems. It is now even moving beyond the earth's atmosphere to space, an environment that is hostile to all forms of life. In this respect, we can see the first moon landing as an anticipatory metastasis.

Human beings have survived and prevailed not only by learning to exploit all ecosystems and their living components, but by learning to exploit other organic and inorganic resources such as oil, natural gas, and minerals. The human species is adept at finding ways to convert the most unlikely substances either to food for itself or to some highly adaptive adjunct of environments necessary for humans. There is a serious question whether elimination of the entire planetary nonhuman natural environment would prevent survival of the human species because of the species' ability to adapt or to convert resources to its use.

It is possible, of course, that the human species will recognize what it is doing to the planet in time to reverse the trend and restore the natural ecosystem to conditions that prevailed prior to human intervention. It is also possible that the human species will succeed in continued growth by converting all materials on the planet to human use. An important problem with this possibility is that the human species evolved in complex ecosystems. Are we smart enough to run an ecosystem complex enough to sustain us? "Trying to make nature stable gets you nowhere" (Schaffer, 1990). On just the atmosphere alone, we are running an uncontrolled experiment in what may prove to be the largest closed garage in the known universe.

A chief tendency of the human species is to simplify ecosystems everywhere. Simplified ecosystems are inherently unstable and tend to collapse. We have greatly simplified our prey-predator relationships; this increases the likelihood of experiencing sharp and uncontrollable oscillations in both our life support systems and our own population levels. Human culture has removed the constraints that result in damped oscillations characteristic of most species. We have not yet recognized or acknowledged any negative feedback loops that seriously endanger our survival as a species even though they loom before us. The result is unregulated growth and potentially lethal population instability that degenerates to figurative, literal, and mathematical chaos.

Chaos theory predicts that undamped oscillations proceed to extinction as a function of increasing rates of growth (May, 1974; May, 1976a; May, 1976b; May & Oster, 1976; Southwood, 1976; Schaffer & Kot, 1985). Small changes in initial conditions, especially in growth rates, may result in large, deterministic, but unpredictable oscillations in future population cycles. Our experience with other biological species and our own recent history should tell us that we are dangerously close to irretrievable chaos if we have not already long since established the pattern that will lead to that result. Is it possible that the increase in the human population growth from 0.001% per year to 0.1% per year at the end of the Paleolithic led us to enter a deterministic chaotic regime that spans thousands of years and which we cannot foresee? Is it likely that we will completely escape the ecological restraints experienced by other species (Woodwell, 1985)? Is it likely that, for humans, there is no limit to the "carrying capacity" of the earth's ecosystem? If there is a limit, how much longer will it take us to arrive at it (von Foerster et al, 1960)? What will happen when we do?

The purpose of any hypothesis is to explain reality and predict events. The hypothesis that the human species is a global malignant neoplasm, a ecopathological process, does provide

a unifying explanation of a wide variety of events and phenomena including rapid human population growth, widespread human destruction of local, regional and continental environments as well as the global ecosystem, rapid urbanization, global atmospheric changes, widespread anthropogenic species extinctions, resistance to population regulation, and numerous other observations. It is a potentially reversible phenomenon and therefore a refutable hypothesis. The human species is capable of regulating its fertility and population growth, it is capable of restoring environments and saving other species from extinction, and it is capable of living in harmony with the rest of the ecosystem.

This hypothesis predicts that, while the human species is capable of all these non-cancerous activities and even occasionally displays them, it will continue to behave overall as a cancer on the planet.

Perhaps the chaos model is more explanatory than the model of a global malignancy. Perhaps it is a combination of these, or, as Brooks and Wiley (1986) assert, the species is a manifestation of the evolutionary trend in the direction of increased entropy. Polgar (1961) asserted that evolution retards entropy, whereas human epicultural systems increase the complexity of structures that increasingly modify the natural environment: "...much of the land surface of the earth is part of a single ecological system united by the human species and the organisms associated with it" (p. 105). Virtually everything human beings do increases entropy (Polgar, 1961; Goldman, 1970). Wars, especially the Vietnam War, result in large increases in entropy (Orians & Pfeiffer, 1970). The biological inefficiency and cultural adaptations of human beings makes the species an entropy sink, with the urban community a kind of nodal concentration point of entropy. Perhaps the planet has, in the human species, a case of malignant entropy, with global warming as one of the manifestations, somewhat like the malaria or heat stroke patient with a case of "malignant hyperpyrexia" (Bruce-Chwatt, 1971).

Human culture is both a major global source of ecosystem regulatory disturbance and the only hope, short of human extinction, for reversing the process and restoring the ecosystem.

A New Species

In order to describe the phenomenon of this malignant, omni-ecophagic species, I propose that the new scientific name of the human species be *homo ecophagus* (homo = man (L.); oikos = house, also the traditional root for "ecosystem" (Gr.); phagos = glutton (Gr.)--"the man who devours the ecosystem."

I propose that the general term that should be used for *homo ecophagus* be "Protoneontos." We may aspire to a new, global state of consciousness of the need to preserve our common ecosystem; that would be an important departure from traditional human behavior, a "new being" - Neontos (neos = new, fresh; also strange, unexpected (Liddell & Scott, 1958) (Gr.); and ontos = being (Gr.). Protoneontos, the first of the new beings and antecedent to

Neontos, is destroying the planetary ecosystem. The forerunner of Protoneontos, Paleoneontos, a.k.a, *homo sapiens*, "wise man," did not.

The Final Diagnosis

The new human species, *homo ecophagus*, is a ubiquitous, predatory, omnivorous species that is a malignant epiecopathologic process engaged in the conversion of all planetary material into human biomass or its support system with coincident terminal derangement of the global ecosystem.

Conclusion

The idea that the human population is a planetary cancer is a profoundly disturbing conclusion, but the observations of the scientific community over the last 20 years have provided massive support for this hypothesis and little, if anything, to refute it. It is exceedingly rare that any cancer ever voluntarily or spontaneously stops being a cancer. If the human species can stop being a cancer, it will either be one of those remarkable exceptions, or my hypothesis is wrong. I will gladly accept either result.

REFERENCES

- Aaby, P., Bukh, J., Lisse, I.M., and Smits, A.J. (1983). Spacing, crowding, and child mortality in Guinea-Bissau. *The Lancet*, July 16, p. 161.
- Abernethy, V. (1979). *Population pressure and cultural adjustment*. New York: Human Sciences Press.
- Anderson, W.A.D. (1961). *Pathology*. Fourth Edition. St. Louis: C.V. Mosby Company.
- Angel, J.L. (1975.). Paleoecology, paleodemography, and health. In S. Polgar (Ed.). *Population, ecology, and social evolution*. The Hague: Mouton.
- Bartlett, A.A. (1978). Forgotten fundamentals of the energy crisis. *American Journal of Physics*. 46(9), 876-888.
- Benard, M.A. (1989). *Our precarious habitat: Fifteen years later*. New York: John Wiley & Sons.
- Birdsell, J.B. (1957). Some population problems involving Pleistocene man. In *Cold Spring Harbor Symposia on Quantitative Biology, Vol. 22. Population Studies: Animal Ecology and Demography*. Cold Spring Harbor, L.I., NY: The Biological Laboratory.
- Birdsell, J.B. (1968). Some predictions for the Pleistocene based on equilibrium systems among recent hunter-gatherers. In R. B. Lee and I. DeVore (Eds.). *Man the hunter*. Chicago: Aldine.
- Bougehey, A.S. (1973). *Ecology of populations*. Second Edition. New York: Macmillan Company.
- Boulding, K.E. (1978). *Ecodynamics: A new theory of societal evolution*. Beverly Hills, CA: Sage Publications.
- Boyd, G.M. (1988, Sept. 27). Bush camp offers a clarified stand about abortion: Candidate wouldn't penalize women but would press to punish physicians. *N.Y. Times*, p.1.

- Brooks, D.R., & Wiley, E.O. (1986). *Evolution as entropy: Toward a unified theory of biology*. Chicago: University of Chicago Press.
- Bruce-Chwatt, L.J. (1971). Malaria. In P. B. Besson and W. McDermott (Eds.). *Cecil-Loeb textbook of medicine*. Philadelphia: W.B. Saunders Co.
- Calhoun, J.C. (1962). Population density and social pathology. *Scientific American*, February, 1962.
- Cassel, J. (1964). Social science theory as a source of hypotheses in epidemiological research. *American Journal of Public Health*, 54 (9), 1482-1488.
- Cassel, J. (1971). Health consequences of population density and crowding. In R. Revelle (Ed.). *Rapid population growth: Consequences and policy implications*. Baltimore: Johns Hopkins Press.
- Carver, N.F. (1979). *Italian hilltowns*. Kalamazoo MI: Documan Press, Ltd.
- Chapin, F.S., Jr., & Weiss, S.F., (Eds.). (1962) *Urban growth dynamics in a regional cluster of cities*. New York: John Wiley & Sons.
- Christian, J.J. (1980). Endocrine factors in population regulation. In M. N. Cohen, R. S. Malpass, & H. G. Klein (Eds.). *Biosocial mechanisms of population regulation*. New Haven: Yale University Press.
- Clark, L.R. (1964). The population dynamics of *Cardiaspina albitextura* (Psyllidae). *Australian Journal of Zoology*, 12, 349-361.
- Cohen, M.N. (1977). *The Food crisis in prehistory*. New Haven: Yale University Press.
- Cole, L.C. (1964). The impending emergence of ecological thought. *Bioscience*, 14 (7), 30-32.
- Crosby, A.W. (1986). *Ecological imperialism: The biological expansion of Europe, 900-1900*. Cambridge: Cambridge University Press.
- Daly, H.E., & Cobb, J.B. Jr. (1990). *For the common good: Redirecting the economy toward community, the environment, and a sustainable future*. Boston: Beacon Press.
- Darby, H.C. (1956). The clearing of the woodland in Europe. In W. L. Thomas, Jr. (Ed.), *Man's role in changing the face of the Earth*. Chicago: The University of Chicago Press.
- Davidson, J., & Andrewartha, H.G; (1948). Annual trends in a natural population of thrips *imaginis* (Thysanoptera). *Journal of Animal Ecology*, 17, 193-199; 200-222.
- Deevey, E.S., Jr. (1960). The human population. *Scientific American*, 203 (3), 195-204.
- Demeny, P. (1986). The world demographic situation. In J. Menken (Ed.). *World population & U.S. policy*. New York: Norton.
- Denevan, W. M. (1976) *The native population of the Americas in 1492*. Madison: University of Wisconsin Press.
- Dobyns, H. F. (1983). *Their numbers became thinned: Native American population dynamics in Eastern North America*. Knoxville: University of Tennessee Press.
- Dogon, M., & Kasarda, J.D. (Eds.). (1988). *The metropolis era: Mega-Cities, Vol. 2*. Newbury Park CA: Sage Publications.
- Dumond, D.E. (1975). The limitation of human population: A natural history. *Science*, 187, 713-721.
- Ehrlich, P.R., Ehrlich, A.H., & Holdren, J.P. (1977). *Ecoscience: Population, resources, environment*. San Francisco: W.H. Freeman Company.
- Flawn, P. (1970). Speech at Northwestern University, January, 1970.

- Frisancho, A.R. (1981). *Human adaptation: A functional adaptation*. Ann Arbor: University of Michigan Press.
- Fyfe, W.S. (1981). The environmental crisis: Quantifying geosphere interactions. *Science*, 213, 105-110.
- Geddes, P. (1915). *Cities in evolution*. London: Williams and Norgate, Ltd.
- Gentry, A.H., & Lopez-Parodi, J. (1980). Deforestation and increased flooding of the Upper Amazon. *Science*, 210, 1354-1356.
- Gist, N.P., & Fava, S.F. (1964). *Urban society. Fifth edition*. New York: Thomas Y. Crowell.
- Goldman, M.I. (1970). The convergence of environmental disruption. *Science*, 170, 37-42.
- Gomez-Pompa, A., Vazquez-Yanes, C., & Guevara, S. (1973). The tropical rain forest: A nonrenewable resource. *Science*, 181, 762-766.
- Goudie, A. (1982). *The human impact: Man's role in environmental change*. Cambridge, MA: MIT Press.
- Graedel, T.E., & Crutzen, P.J. (1989). The changing atmosphere. *Scientific American*, 261 (3), 58-68.
- Gregg, A. (1955). A medical aspect of the population problem. *Science*, 121, 681-682. In G.Hardin (Ed.). *Population, evolution, and birth control: A collage of controversial essays*. San Francisco: W.H. Freeman Company.
- Gruen, V. (1973). *Centers for the urban environment: Survival of the cities*. New York: Van Nostrand Reinhold Company.
- Hafele, W. (1980). A global and long-range picture of energy developments. *Science*, 209, 174-182.
- Hassan, F.A. (1978). Prehistoric demography. In M. Schiffer (Ed.). *Advances in archeological method and theory, Vol. 1*. New York: Academic Press.
- Hassan, F.A. (1980). The growth and regulation of human population in prehistoric times. In M. N. Cohen, R. S. Malpass, & H. G. Klein (Eds.). *Biosocial mechanisms of population regulation*. New Haven: Yale University Press.
- Hassan, F.A. (1981). *Demographic archeology*. New York: Academic Press.
- Hecht, S., & Cockburn, A. (1989). *The fate of the forest: Developers, destroyers, and defenders of the Amazon*. London: Verso.
- Hern, W.M. (1976). Knowledge and use of herbal contraceptives in a Peruvian Amazon village. *Human Organization*, 35, 9-19.
- Hern, W.M. (1977). High fertility in a Peruvian Amazon Indian village. *Human Ecology*, 5, 355-368.
- Hern, W.M. (1988). Polygyny and fertility among the Shipibo: An epidemiologic test of an ethnographic hypothesis. Unpublished Ph.D. dissertation, University of North Carolina School of Public Health.
- Hern, W.M. (1990). Health and demography of native Amazonians. In A. Roosevelt (Ed.). *Amazonian synthesis* (in press).
- Hoage, R.J. (1985). *Animal extinctions: What everyone should know*. Washington, D.C.: Smithsonian Institution Press.
- Hoover, E.M. (1948). *The location of economic activity*. New York: McGraw-Hill.

- Johnson, J.H. (1972). *Urban geography: An introductory analysis*. Second Edition. Oxford: Pergamon Press.
- Jordan, T.G., & Rowntree, L. (1986). *The human mosaic: A thematic introduction to cultural geography*. New York: Harper & Row.
- Keyfitz, N. (1989). The growing human population. *Scientific American*, 261 (3), 119-126.
- La Brecque, M. (1986/7). Fractal applications. *Mosaic*, 17 (4), 34-48.
- Lathrap, D.W. (1970). *The Upper Amazon*. New York: Praeger.
- Leopold, A. (1943). Deer irruptions. *Wisconsin Conservation Bulletin*, August. Reprinted in Wisconsin Conservation Department Publication, 321, 3-11.
- Liddell & Scott (1958). *A lexicon. Abridged from Liddell & Scott's Greek-English Lexicon*. Oxford: Clarendon Press.
- Lovelock, J.E. (1979). *Gaia: A new look at life on earth*. Oxford: Oxford University Press.
- MacLulich, D.A. (1937). Fluctuations in the numbers of the varying hare (*Lepus americanus*). *University of Toronto Studies, Biology Series*, No. 43.
- Malthus, T.R. (1798). An essay on the principle of population. In P. Appleman (Ed.). *An essay on the principle of population*. New York: W.W. Norton Company.
- Margalef, R. (1968). *Perspectives in ecological theory*. Chicago: University of Chicago Press.
- Martin, P.S. (1973). The discovery of America. *Science*, 179, 969-974.
- May, R.M. (1976). Models for single populations. In R. M. May (Ed.). *Theoretical ecology: Principles and applications* (pp 4-25). Philadelphia: W.B. Saunders Co.
- May, R.M. (1976). Simple mathematical models with very complicated dynamics. *Nature*, 261 (5560), 459-467.
- May, R.M. (1974). Biological populations with nonoverlapping generations: Stable points, stable cycles, and chaos. *Science*, 186 (4164), 645-647.
- May, R.M., and Oster, G.F. (1976). Bifurcations and dynamic complexity in simple ecological models. *The American Naturalist*, 110 (1974), 573-599.
- McHarg, I. (1969). *Design with nature*. Garden City, NY: Doubleday/Natural History Press.
- Menken, J. (1986). Introduction and overview. In Jane Menken (Ed.). *World population & U.S. policy: The choices ahead*. New York: W.W. Norton & Company.
- Mooney, H. (1988). *Toward an understanding of global change: Initial priorities for U.S. contributions to the international geosphere-biosphere program*. Washington, D.C: National Academy Press.
- Moran, E.F. (1982). *Human adaptability: An introduction to ecological anthropology*. Boulder, CO: Westview Press.
- Moriarty, F. (1988). *Ecotoxicology: The study of pollutants in ecosystems*. Second Edition. San Diego, CA: Academic Press.
- Mumford, L. (1961). *The city in history*. N.Y.: Harcourt, Brace and World.
- Myers, N. (1984). *Gaia: An atlas of planet management*. New York: Doubleday.
- Myers, T.P. (1988). El efecto de las pestes sobre las poblaciones de la Amazonia Alta. *Amazonia Peruana* 15, 61-81.
- Nag, M. (1962). *Factors affecting human fertility in nonindustrial societies: A cross-cultural study*. New Haven: HRAF Press.

- Odum, E.P. (1971). *Fundamentals of ecology*. Third Edition. Philadelphia PA: Saunders College Publishing.
- Odum, E.P. (1989). *Ecology and our endangered life-support systems*. Sunderland, MA: Sinauer Associates, Inc.
- Orians, G.H., & Pfeiffer, E.W. (1970). Effects of defoliation with herbicides in the Vietnam war. *Science*, 168, 544-554.
- Perez-Tamayo, R. (1961). *Mechanisms of disease: An introduction to pathology*. Philadelphia: W.B. Saunders Company.
- Polgar, S. (1961) Evolution and the thermodynamic imperative. *Human Biology*, 33 (2), 99-109.
- Polgar, S. (1969). Cultural aspects of natality regulation techniques. *Proceedings of the VIIIth International Congress of Anthropological and Ethnological Sciences, Tokyo, 1968*, Vol. 3, pp.. 232-234.
- Posey, D.A. (1983). Indigenous knowledge and development: an ideological bridge to the future. *Ciencia e Cultura*, 35(7), 877-894.
- Prescott, D.M. (March, 1990). Personal communication. Boulder, Colo.
- Prescott, D.M., & Flexer, A.S. (1986). *Cancer: The misguided cell*. Second edition. Sunderland, MA: Sinauer Associates Inc.
- Rambler, M.B., Margulis, L., & Fester, R. (1989). *Global ecology: Towards a science of the biosphere*. San Diego, CA: Academic Press.
- Rasmussen, D.I. (1941). Biotic communities of Kaibab Plateau, Arizona. *Ecological Monographs*, 11, 230-275.
- Repetto, R. (1989). Renewable resources and population growth: past experiences and future prospects. *Population and Environment*, 10(4), 221-236.
- Roosevelt, A.C. (1980). *Parmana: Prehistoric maize and manioc subsistence along the Amazon and Orinoco*. New York: Academic Press.
- Ruddon, R.W. (1987). *Cancer biology*. Second Edition. New York: Oxford University Press.
- Russell, P. (1983). *The global brain: Speculations on the evolutionary leap to planetary consciousness*. Los Angeles, CA: J.P. Tarcher, Inc.
- Sagan, C., Toon, O.B., & Pollack, J.B. (1979). Anthropogenic albedo changes and the earth's climate. *Science*, 206, 1363-1368.
- Sahlins, M.D. (1961). The segmentary lineage: An organization of predatory expansion. *American Anthropologist*, 63, 322-345.
- Sahtouris, E. (1989). *Gaia: The human journey from chaos to cosmos*. New York: Simon, Schuster.
- Saucier, J.F. (1972). Correlates of the post-partum taboo: A cross-cultural study. *Current Anthropology* 13, 238-249.
- SCEP. (1979). *Man's impact on the global environment: Reprint of the Study of Critical Environmental Problems (SCEP)*. Cambridge, MA: MIT Press.
- Schaffer, W.M. & Kot, M. (1985). Do strange attractors govern ecological systems? *BioScience*, 35 (6), 342-350.
- Schaffer, W.M. (1990). Chaos: Its essentials and potential implications for ecology. Presentation at the annual meeting of the American Association for the Advancement of Science, New Orleans, Louisiana, February 19.

- Schneider, S.H. (1989). The changing climate. *Scientific American*, 261 (3), 70:79.
- Southwood, T.R.E. (1976). Binomic strategies and population parameters. In R. M. May (Ed.). *Theoretical ecology: Principles and applications* (pp. 26-48). Philadelphia: W.B. Saunders Co.
- Taber, R.D., & Dasmann, R.F. (1957). The dynamics of three natural populations of the deer *Odocoileus hemionus columbianus*. *Ecology*, 38, 233-246.
- Tinker, I., Reining, P., Swidler, W., & Cousins, W. (1976). *Culture and population change*. Washington, D.C: American Association for the Advancement of Science.
- von Foerster, H., Mora, P.M., & Amiot, L.W. (1960). Doomsday: Friday, 13 November, A.D. 2026. *Science*, 131, 1291-1295.
- Weeks, J.R. (1989). *Population*. Fourth Edition. Belmont, CA: Wadsworth Publishing Company.
- Wilson, E.O., & Bossert, W.H. (1971). *A primer of population biology*. Sunderland, MA: Sinauer Associates, Inc.
- Wilson, E.O. (Ed.) (1988). *Biodiversity*. Washington, D.C.: National Academy Press.
- Wilson, E.O. (1990). Interview on the NBC Today show, March 7.
- Woodwell, G.M. (1985). On the limits of nature. In R. Repetto (Ed.). *The global possible: Resources, development, and the new century*. New Haven: Yale University Press.
- Yonge, C.M. (1963). The biology of coral reefs. *Advances in Marine Biology*, 1, 209-260.
- Ziswiler, V. (1967). *Extinct and vanishing animals: A biology of extinction and survival*. English edition by F. and P. Bunnell. New York: Springer-Verlag.

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