AP Environmental Science
Summer Assignment
Instructor: Mrs. Cangelosi
Email: fcangelosi@tka.net

Summer Assignment #1: 30 points

"THE TRAGEDY OF THE COMMONS" READING ANALYSIS

Directions:

- **Watch this video: https://www.youtube.com/watch?v=CxC161GvMPc**
- **Watch this video: https://www.youtube.com/watch?v=bs2P0wRod8U**
- **Go to http://www.sciencemag.org/content/162/3859/1243.full and read "The Tragedy of the Commons" by Garrett Hardin.** Science13December1968: Vol.162no.3859pp.1243-124
- **Answer the following questions using complete sentences**.

Analysis Questions:

1. In his first few paragraphs, Garrett Hardin implies that there are a class of problems for which there is no technical solution. What is his definition of a technical solution?

2. Explain the analogy the author makes between the population problem and a game.

3. To address the question "what shall we maximize?" Hardin concepts such as finite vs infinite, the greatest number vs. the greatest good, maintenance calories vs work calories, and individual decision vs common good. Discuss how one of these pairs of opposites relates to the population problem.

4. According to the author, is ours a finite world? Explain.

5. What is Bentham's goal? How does the author feel about reaching this goal?

6. What are incommensurables? What is the criterion in nature?

7. Explain Adam Smith's idea of the "invisible hand" and what does this say about human selfishness?

8. Explain the author's analogy about the herdsman, personal gain, and what happens to freedom in a Commons; the "philosophy of the commons".

9. Why is the statement, ""Flowing water purifies itself every 10 miles," no longer true?

10. How is pollution the "reverse" tragedy of the commons?

11. What did the United Nations declare in 1967? Why does Garrett Hardin find fault with it?

12. What did Charles Galton Darwin (Darwin's grandson) explain about the self-eliminating nature of conscience?

13. What example does the author give for "mutual coercion mutually agreed upon"?

14. What is Hegel's quote about freedom? With what plea does Hardin end his essay "The Tragedy of the Commons"?

15. *Explain* how each of these scenarios is or is not an example of Tragedy of the Commons:

    a. When North America was settled, forests covered the land. People cut them down for wood and to clear land for farms.

    b. Blackberries are growing in a public park. They are sweetest when they are black. People walking through the park pick the black ones first and then go on to pick red ones, not waiting for them to fully ripen.

    c. Weyerhauser, a paper company, owns a forest where it cuts trees for its paper products. It clear-cuts huge areas of forest, leaving them desolate without vegetation.

    d. About 10,000 years ago, many great mammals lived in North America, including saber-toothed cats, dire wolves, and mammoths. They went extinct as a result of hunting by Native Americans.

    e. The air over Mexico City is heavily polluted by many unregulated factories and heavy traffic.

Summer Assignment #2: 30 points

Directions:

- Read the article "6,000,000,000 Consumption Machines - Environmental Aspects of Population Growth"
- Answer discussion questions 1 and 2 using complete sentences in paragraph form. Do not write the question. Minimum length - 2 pages typed. 11pt font

Discussion Questions:

1. Summarize the consequence of human population growth on the following: (24 pts)
Water; Forest; Air; Soil; Ocean; Animals

2. Discuss *at least* two scenarios depicted in this article that relate to the "Tragedy of the Commons". (6 pts)

The Tragedy of the Commons

Garrett Hardin

At the end of a thoughtful article on the future of nuclear war, Wiesner and York (*1*) concluded that: "Both sides in the arms race are . . . confronted by the dilemma of steadily increasing military power and steadily decreasing national security. *It is our considered professional judgment that this dilemma has no technical solution.* If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation."

I would like to focus your attention not on the subject of the article (national security in a nuclear world) but on the kind of conclusion they reached, namely that there is no technical solution to the problem. An implicit and almost universal assumption of discussions published in professional and semipopular scientific journals is that the problem under discussion has a technical solution. A technical solution may be defined as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality.

In our day (though not in earlier times) technical solutions are always welcome. Because of previous failures in prophecy, it takes courage to assert that a desired technical solution is not possible. Wiesner and York exhibited this courage; publishing in a science journal, they insisted that the solution to the problem was not to be found in the natural sciences. They cautiously qualified their statement with the phrase, "It is our considered professional judgment. . . ." Whether they were right or not is not the concern of the present article. Rather, the concern here is with the important concept of a class of human problems which can be called "no technical solution problems," and, more specifically, with the identification and discussion of one of these.

It is easy to show that the class is not a null class. Recall the game of tick-tack-toe. Consider the problem, "How can I win the game of tick-tack-toe?" It is well known that I cannot, if I assume (in keeping with the conventions of game theory) that my opponent understands the game perfectly. Put another way, there is no "technical solution" to the problem. I can win only by giving a radical meaning to the word "win." I can hit my opponent over the head; or I can drug him; or I can falsify the records. Every way in which I "win" involves, in some sense, an abandonment of the game, as we intuitively understand it. (I can also, of course, openly abandon the game—refuse to play it. This is what most adults do.)

The class of "No technical solution problems" has members. My thesis is that the "population problem," as conventionally conceived, is a member of this class. How it is conventionally conceived needs some comment. It is fair to say that most people who anguish over the population problem are trying to find a way to avoid the evils of overpopulation without relinquishing any of the privileges they now enjoy. They think that farming the seas or developing new strains of wheat will solve the problem—technologically. I try to show here that the solution they seek cannot be found. The population problem cannot be solved in a technical way, any more than can the problem of winning the game of tick-tack-toe.

What Shall We Maximize?

Population, as Malthus said, naturally tends to grow "geometrically," or, as we would now say, exponentially. In a finite world this means that the per capita share of the world's goods must steadily decrease. Is ours a finite world?

A fair defense can be put forward for the view that the world is infinite; or that we do not know that it is not. But, in terms of the practical problems that we must face in the next few generations with the foreseeable technology, it is clear that we will greatly increase human misery if we do not, during the immediate future, assume that the world available to the terrestrial human population is finite. "Space" is no escape (*2*).

A finite world can support only a finite population; therefore, population growth must eventually equal zero. (The case of perpetual wide fluctuations above and below zero is a trivial variant that need not be discussed.) When this condition is met, what will be the situation of mankind? Specifically, can Bentham's goal of "the greatest good for the greatest number" be realized?

No—for two reasons, each sufficient by itself. The first is a theoretical one. It is not mathematically possible to maximize for two (or more) variables at the same time. This was clearly stated by von Neumann and Morgenstern (*3*), but the principle is implicit in the theory of partial differential equations, dating back at least to D'Alembert (1717–1783).

The second reason springs directly from biological facts. To live, any organism must have a source of energy (for example, food). This energy is utilized for two purposes: mere maintenance and work. For man, maintenance of life requires about 1600 kilocalories a day ("maintenance calories"). Anything that he does over and above merely staying alive will be defined as work, and is supported by "work calories" which he takes in. Work calories are used not only for what we call work in common speech; they are also required for all forms of enjoyment, from swimming and automobile racing to playing music and writing poetry. If our goal is to maximize population it is obvious what we must do: We must make the work calories per person approach as close to zero as possible. No gourmet meals, no vacations, no sports, no music, no literature, no art. . . . I think that everyone will grant, without argument or proof, that maximizing population does not maximize goods. Bentham's goal is impossible.

In reaching this conclusion I have made the usual assumption that it is the acquisition of energy that is the problem. The appearance of atomic energy has led some to question this assumption. However, given an infinite source of energy, population growth still produces an inescapable problem. The problem of the acquisition of energy is replaced by the problem of its dissipation, as J. H. Fremlin has so wittily shown (*4*). The arithmetic signs in the analysis are, as it were, reversed; but Bentham's goal is still unobtainable.

The optimum population is, then, less than the maximum. The difficulty of defining the optimum is enormous; so far as I know, no one has seriously tackled this problem. Reaching an acceptable and stable solution will surely require more than one generation of hard analytical work—and much persuasion.

We want the maximum good per person; but what is good? To one person it is wilderness, to another it is ski lodges for thousands. To one it is estuaries to nourish ducks for hunters to shoot; to another it is factory land. Comparing one good with another is, we usually say, impossible because goods are incommensurable. Incommensurables cannot be compared.

The author is professor of biology, University of California, Santa Barbara. This article is based on a presidential address presented before the meeting of the Pacific Division of the American Association for the Advancement of Science at Utah State University, Logan, 25 June 1968.

Theoretically this may be true; but in real life incommensurables are commensurable. Only a criterion of judgment and a system of weighting are needed. In nature the criterion is survival. Is it better for a species to be small and hideable, or large and powerful? Natural selection commensurates the incommensurables. The compromise achieved depends on a natural weighting of the values of the variables.

Man must imitate this process. There is no doubt that in fact he already does, but unconsciously. It is when the hidden decisions are made explicit that the arguments begin. The problem for the years ahead is to work out an acceptable theory of weighting. Synergistic effects, nonlinear variation, and difficulties in discounting the future make the intellectual problem difficult, but not (in principle) insoluble.

Has any cultural group solved this practical problem at the present time, even on an intuitive level? One simple fact proves that none has: there is no prosperous population in the world today that has, and has had for some time, a growth rate of zero. Any people that has intuitively identified its optimum point will soon reach it, after which its growth rate becomes and remains zero.

Of course, a positive growth rate might be taken as evidence that a population is below its optimum. However, by any reasonable standards, the most rapidly growing populations on earth today are (in general) the most miserable. This association (which need not be invariable) casts doubt on the optimistic assumption that the positive growth rate of a population is evidence that it has yet to reach its optimum.

We can make little progress in working toward optimum population size until we explicitly exorcize the spirit of Adam Smith in the field of practical demography. In economic affairs, *The Wealth of Nations* (1776) popularized the "invisible hand," the idea that an individual who "intends only his own gain," is, as it were, "led by an invisible hand to promote . . . the public interest" (5). Adam Smith did not assert that this was invariably true, and perhaps neither did any of his followers. But he contributed to a dominant tendency of thought that has ever since interfered with positive action based on rational analysis, namely, the tendency to assume that decisions reached individually will, in fact, be the best decisions for an entire society. If this assumption is correct it justifies the continuance of our present policy of laissez-faire in reproduction. If it is correct we can assume that men will control their individual fecundity so as to produce the optimum population. If the assumption is not correct, we need to reexamine our individual freedoms to see which ones are defensible.

Tragedy of Freedom in a Commons

The rebuttal to the invisible hand in population control is to be found in a scenario first sketched in a little-known pamphlet (6) in 1833 by a mathematical amateur named William Forster Lloyd (1794–1852). We may well call it "the tragedy of the commons," using the word "tragedy" as the philosopher Whitehead used it (7): "The essence of dramatic tragedy is not unhappiness. It resides in the solemnity of the remorseless working of things." He then goes on to say, "This inevitableness of destiny can only be illustrated in terms of human life by incidents which in fact involve unhappiness. For it is only by them that the futility of escape can be made evident in the drama."

The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.

As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, "What is the utility *to me* of adding one more animal to my herd?" This utility has one negative and one positive component.

1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.

2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of −1.

Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another. . . . But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

Some would say that this is a platitude. Would that it were! In a sense, it was learned thousands of years ago, but natural selection favors the forces of psychological denial (8). The individual benefits as an individual from his ability to deny the truth even though society as a whole, of which he is a part, suffers.

Education can counteract the natural tendency to do the wrong thing, but the inexorable succession of generations requires that the basis for this knowledge be constantly refreshed.

A simple incident that occurred a few years ago in Leominster, Massachusetts, shows bow perishable the knowledge is. During the Christmas shopping season the parking meters downtown were covered with plastic bags that bore tags reading: "Do not open until after Christmas. Free parking courtesy of the mayor and city council." In other words, facing the prospect of an increased demand for already scarce space. the city fathers reinstituted the system of the commons. (Cynically, we suspect that they gained more votes than they lost by this retrogressive act.)

In an approximate way, the logic of the commons has been understood for a long time, perhaps since the discovery of agriculture or the invention of private property in real estate. But it is understood mostly only in special cases which are not sufficiently generalized. Even at this late date, cattlemen leasing national land on the western ranges demonstrate no more than an ambivalent understanding, in constantly pressuring federal authorities to increase the head count to the point where overgrazing produces erosion and weed-dominance. Likewise, the oceans of the world continue to suffer from the survival of the philosophy of the commons. Maritime nations still respond automatically to the shibboleth of the "freedom of the seas." Professing to believe in the "inexhaustible resources of the oceans," they bring species after species of fish and whales closer to extinction (9).

The National Parks present another instance of the working out of the tragedy of the commons. At present, they are open to all, without limit. The parks themselves are limited in extent—there is only one Yosemite Valley—whereas population seems to grow without limit. The values that visitors seek in the parks are steadily eroded. Plainly, we must soon cease to treat the parks as commons or they will be of no value to anyone.

What shall we do? We have several options. We might sell them off as private property. We might keep them as public property, but allocate the right to enter them. The allocation might be on the basis

of wealth, by the use of an auction system. It might be on the basis of merit, as defined by some agreed-upon standards. It might be by lottery. Or it might be on a first-come, first-served basis, administered to long queues. These, I think, are all the reasonable possibilities. They are all objectionable. But we must choose—or acquiesce in the destruction of the commons that we call our National Parks.

Pollution

In a reverse way, the tragedy of the commons reappears in problems of pollution. Here it is not a question of taking something out of the commons, but of putting something in—sewage, or chemical, radioactive, and heat wastes into water; noxious and dangerous fumes into the air, and distracting and unpleasant advertising signs into the line of sight. The calculations of utility are much the same as before. The rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. Since this is true for everyone, we are locked into a system of "fouling our own nest," so long as we behave only as independent, rational, free-enterprisers.

The tragedy of the commons as a food basket is averted by private property, or something formally like it. But the air and waters surrounding us cannot readily be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means, by coercive laws or taxing devices that make it cheaper for the polluter to treat his pollutants than to discharge them untreated. We have not progressed as far with the solution of this problem as we have with the first. Indeed, our particular concept of private property, which deters us from exhausting the positive resources of the earth, favors pollution. The owner of a factory on the bank of a stream—whose property extends to the middle of the stream, often has difficulty seeing why it is not his natural right to muddy the waters flowing past his door. The law, always behind the times, requires elaborate stitching and fitting to adapt it to this newly perceived aspect of the commons.

The pollution problem is a consequence of population. It did not much matter how a lonely American frontiersman disposed of his waste. "Flowing water purifies itself every 10 miles," my grandfather used to say, and the myth was near enough to the truth when he was a boy, for there were not too many people. But as population became denser, the natural chemical and biological recycling processes became overloaded, calling for a redefinition of property rights.

How To Legislate Temperance?

Analysis of the pollution problem as a function of population density uncovers a not generally recognized principle of morality, namely: *the morality of an act is a function of the state of the system at the time it is performed* (*10*). Using the commons as a cesspool does not harm the general public under frontier conditions, because there is no public, the same behavior in a metropolis is unbearable. A hundred and fifty years ago a plainsman could kill an American bison, cut out only the tongue for his dinner, and discard the rest of the animal. He was not in any important sense being wasteful. Today, with only a few thousand bison left, we would be appalled at such behavior.

In passing, it is worth noting that the morality of an act cannot be determined from a photograph. One does not know whether a man killing an elephant or setting fire to the grassland is harming others until one knows the total system in which his act appears. "One picture is worth a thousand words," said an ancient Chinese; but it may take 10,000 words to validate it. It is as tempting to ecologists as it is to reformers in general to try to persuade others by way of the photographic shortcut. But the essense of an argument cannot be photographed: it must be presented rationally—in words.

That morality is system-sensitive escaped the attention of most codifiers of ethics in the past. "Thou shalt not . . ." is the form of traditional ethical directives which make no allowance for particular circumstances. The laws of our society follow the pattern of ancient ethics, and therefore are poorly suited to governing a complex, crowded, changeable world. Our epicyclic solution is to augment statutory law with administrative law. Since it is practically impossible to spell out all the conditions under which it is safe to burn trash in the back yard or to run an automobile without smog-control, by law we delegate the details to bureaus. The result is administrative law, which is rightly feared for an ancient reason—*Quis custodiet ipsos custodes*?—"Who shall watch the watchers themselves?" John Adams said that we must have "a government of laws and not men." Bureau administrators, trying to evaluate the morality of acts in the total system, are singularly liable to corruption, producing a government by men, not laws.

Prohibition is easy to legislate (though not necessarily to enforce); but how do we legislate temperance? Experience indicates that it can be accomplished best through the mediation of administrative law. We limit possibilities unnecessarily if we suppose that the sentiment of *Quis custodiet* denies us the use of administrative law. We should rather retain the phrase as a perpetual reminder of fearful dangers we cannot avoid. The great challenge facing us now is to invent the corrective feedbacks that are needed to keep custodians honest. We must find ways to legitimate the needed authority of both the custodians and the corrective feedbacks.

Freedom To Breed Is Intolerable

The tragedy of the commons is involved in population problems in another way. In a world governed solely by the principle of "dog eat dog"—if indeed there ever was such a world—how many children a family had would not be a matter of public concern. Parents who bred too exuberantly would leave fewer descendants, not more, because they would be unable to care adequately for their children. David Lack and others have found that such a negative feedback demonstrably controls the fecundity of birds (*11*). But men are not birds, and have not acted like them for millenniums, at least.

If each human family were dependent only on its own resources; if the children of improvident parents starved to death; *if*, thus, overbreeding brought its own "punishment" to the germ line—*then* there would be no public interest in controlling the breeding of families. But our society is deeply committed to the welfare state (*12*), and hence is confronted with another aspect of the tragedy of the commons.

In a welfare state, how shall we deal with the family, the religion, the race, or the class (or indeed any distinguishable and cohesive group) that adopts overbreeding as a policy to secure its own aggrandizement (*13*)? To couple the concept of freedom to breed with the belief that everyone born has an equal right to the commons is to lock the world into a tragic course of action.

Unfortunately this is just the course of action that is being pursued by the United Nations. In late 1967, some 30 nations agreed to the following (*14*):

> The Universal Declaration of Human Rights describes the family as the natural and fundamental unit of society. It follows that any choice and decision with regard to the size of the family must irrevocably rest with the family itself, and cannot be made by anyone else.

It is painful to have to deny categorically the validity of this right; denying it, one feels as uncomfortable as a resident of Salem, Massachusetts, who denied the reality of witches in the 17th century. At the present time, in liberal quarters, something like a taboo acts to inhibit criticism of the United Nations. There is a feeling that the United Nations is "our last and best hope," that we shouldn't find fault with it; we shouldn't play

into the hands of the archconservatives. However, let us not forget what Robert Louis Stevenson said: "The truth that is suppressed by friends is the readiest weapon of the enemy." If we love the truth we must openly deny the validity of the Universal Declaration of Human Rights, even though it is promoted by the United Nations. We should also join with Kingsley Davis (*15*) in attempting to get Planned Parenthood-World Population to see the error of its ways in embracing the same tragic ideal.

Conscience Is Self-Eliminating

It is a mistake to think that we can control the breeding of mankind in the long run by an appeal to conscience. Charles Galton Darwin made this point when he spoke on the centennial of the publication of his grandfather's great book. The argument is straightforward and Darwinian.

People vary. Confronted with appeals to limit breeding, some people will undoubtedly respond to the plea more than others. Those who have more children will produce a larger fraction of the next generation than those with more susceptible consciences. The difference will be accentuated, generation by generation.

In C. G. Darwin's words: "It may well be that it would take hundreds of generations for the progenitive instinct to develop in this way, but if it should do so, nature would have taken her revenge, and the variety *Homo contracipiens* would become extinct and would be replaced by the variety *Homo progenitivus*" (*16*).

The argument assumes that conscience or the desire for children (no matter which) is hereditary—but hereditary only in the most general formal sense. The result will be the same whether the attitude is transmitted through germ cells, or exosomatically, to use A. J. Lotka's term. (If one denies the latter possibility as well as the former, then what's the point of education?) The argument has here been stated in the context of the population problem, but it applies equally well to any instance in which society appeals to an individual exploiting a commons to restrain himself for the general good—by means of his conscience. To make such an appeal is to set up a selective system that works toward the elimination of conscience from the race.

Pathogenic Effects of Conscience

The long-term disadvantage of an appeal to conscience should be enough to condemn it; but has serious short-term disadvantages as well. If we ask a man who is exploiting a commons to desist "in the name of conscience," what are we saying to him? What does he hear? —not only at the moment but also in the wee small hours of the night when, half asleep, he remembers not merely the words we used but also the nonverbal communication cues we gave him unawares? Sooner or later, consciously or subconsciously, he senses that he has received two communications, and that they are contradictory: (i) (intended communication) "If you don't do as we ask, we will openly condemn you for not acting like a responsible citizen"; (ii) (the unintended communication) "If you do behave as we ask, we will secretly condemn you for a simpleton who can be shamed into standing aside while the rest of us exploit the commons."

Everyman then is caught in what Bateson has called a "double bind." Bateson and his co-workers have made a plausible case for viewing the double bind as an important causative factor in the genesis of schizophrenia (*17*). The double bind may not always be so damaging, but it always endangers the mental health of anyone to whom it is applied. "A bad conscience," said Nietzsche, "is a kind of illness."

To conjure up a conscience in others is tempting to anyone who wishes to extend his control beyond the legal limits. Leaders at the highest level succumb to this temptation. Has any President during the past generation failed to call on labor unions to moderate voluntarily their demands for higher wages, or to steel companies to honor voluntary guidelines on prices? I can recall none. The rhetoric used on such occasions is designed to produce feelings of guilt in noncooperators.

For centuries it was assumed without proof that guilt was a valuable, perhaps even an indispensable, ingredient of the civilized life. Now, in this post-Freudian world, we doubt it.

Paul Goodman speaks from the modern point of view when he says: "No good has ever come from feeling guilty, neither intelligence, policy, nor compassion. The guilty do not pay attention to the object but only to themselves, and not even to their own interests, which might make sense, but to their anxieties" (*18*).

One does not have to be a professional psychiatrist to see the consequences of anxiety. We in the Western world are just emerging from a dreadful two-centuries-long Dark Ages of Eros that was sustained partly by prohibition laws, but perhaps more effectively by the anxiety-generating mechanism of education. Alex Comfort has told the story well in *The Anxiety Makers* (*19*); it is not a pretty one.

Since proof is difficult, we may even concede that the results of anxiety may sometimes, from certain points of view, be desirable. The larger question we should ask is whether, as a matter of policy, we should ever encourage the use of a technique the tendency (if not the intention) of which is psychologically pathogenic. We hear much talk these days of responsible parenthood; the coupled words are incorporated into the titles of some organizations devoted to birth control. Some people have proposed massive propaganda campaigns to instill responsibility into the nation's (or the world's) breeders. But what is the meaning of the word responsibility in this context? Is it not merely a synonym for the word conscience? When we use the word responsibility in the absence of substantial sanctions are we not trying to browbeat a free man in a commons into acting against his own interest? Responsibility is a verbal counterfeit for a substantial *quid pro quo*. It is an attempt to get something for nothing.

If the word responsibility is to be used at all, I suggest that it be in the sense Charles Frankel uses it (*20*). "Responsibility," says this philosopher, "is the product of definite social arrangements." Notice that Frankel calls for social arrangements—not propaganda.

Mutual Coercion Mutually Agreed upon

The social arrangements that produce responsibility are arrangements that create coercion, of some sort. Consider bank-robbing. The man who takes money from a bank acts as if the bank were a commons. How do we prevent such action? Certainly not by trying to control his behavior solely by a verbal appeal to his sense of responsibility. Rather than rely on propaganda we follow Frankel's lead and insist that a bank is not a commons; we seek the definite social arrangements that will keep it from becoming a commons. That we thereby infringe on the freedom of would-be robbers we neither deny nor regret.

The morality of bank-robbing is particularly easy to understand because we accept complete prohibition of this activity. We are willing to say "Thou shalt not rob banks," without providing for exceptions. But temperance also can be created by coercion. Taxing is a good coercive device. To keep downtown shoppers temperate in their use of parking space we introduce parking meters for short periods, and traffic fines for longer ones. We need not actually forbid a citizen to park as long as he wants to; we need merely make it increasingly expensive for him to do so. Not prohibition, but carefully biased options are what we offer him. A Madison Avenue man might call this persuasion; I prefer the greater candor of the word coercion.

Coercion is a dirty word to most liberals now, but it need not forever be so. As with the four-letter words, its dirtiness can be cleansed away by exposure to the light, by saying it over and over without apology or embarrassment. To many, the word coercion implies arbitrary decisions of distant and irresponsible bureaucrats; but this is not a necessary part of its meaning. The only kind of coercion I recommend is mutual coercion, mutually agreed upon by the majority of the people affected.

To say that we mutually agree to coercion is not to say that we are required to enjoy it, or even to pretend we enjoy it. Who enjoys taxes? We all grumble about them. But we accept compulsory taxes because we recognize that voluntary taxes would favor the conscienceless. We institute and (grumblingly) support taxes and other coercive devices to escape the horror of the commons.

An alternative to the commons need not be perfectly just to be preferable. With real estate and other material goods, the alternative we have chosen is the institution of private property coupled with legal inheritance. Is this system perfectly just? As a genetically trained biologist I deny that it is. It seems to me that, if there are to be differences in individual inheritance, legal possession should be perfectly correlated with biological inheritance—that those who are biologically more fit to be the custodians of property and power should legally inherit more. But genetic recombination continually makes a mockery of the doctrine of "like father, like son" implicit in our laws of legal inheritance. An idiot can inherit millions, and a trust fund can keep his estate intact. We must admit that our legal system of private property plus inheritance is unjust—but we put up with it because we are not convinced, at the moment, that anyone has invented a better system. The alternative of the commons is too horrifying to contemplate. Injustice is preferable to total ruin.

It is one of the peculiarities of the warfare between reform and the status quo that it is thoughtlessly governed by a double standard. Whenever a reform measure is proposed it is often defeated when its opponents triumphantly discover a flaw in it. As Kingsley Davis has pointed out (*21*), worshippers of the status quo sometimes imply that no reform is possible without unanimous agreement, an implication contrary to historical fact. As nearly as I can make out, automatic rejection of proposed reforms is based on one of two unconscious assumptions: (i) that the status quo is perfect; or (ii) that the choice we face is between reform and no action; if the proposed reform is imperfect, we presumably should take no action at all, while we wait for a perfect proposal.

But we can never do nothing. That which we have done for thousands of years is also action. It also produces evils. Once we are aware that the status quo is action, we can then compare its discoverable advantages and disadvantages with the predicted advantages and disadvantages of the proposed reform, discounting as best we can for our lack of experience. On the basis of such a comparison, we can make a rational decision which will not involve the unworkable assumption that only perfect systems are tolerable.

Recognition of Necessity

Perhaps the simplest summary of this analysis of man's population problems is this: the commons, if justifiable at all, is justifiable only under conditions of low-population density. As the human population has increased, the commons has had to be abandoned in one aspect after another.

First we abandoned the commons in food gathering, enclosing farm land and restricting pastures and hunting and fishing areas. These restrictions are still not complete throughout the world.

Somewhat later we saw that the commons as a place for waste disposal would also have to be abandoned. Restrictions on the disposal of domestic sewage are widely accepted in the Western world; we are still struggling to close the commons to pollution by automobiles, factories, insecticide sprayers, fertilizing operations, and atomic energy installations.

In a still more embryonic state is our recognition of the evils of the commons in matters of pleasure. There is almost no restriction on the propagation of sound waves in the public medium. The shopping public is assaulted with mindless music, without its consent. Our government is paying out billions of dollars to create supersonic transport which will disturb 50,000 people for every one person who is whisked from coast to coast 3 hours faster. Advertisers muddy the airwaves of radio and television and pollute the view of travelers. We are a long way from outlawing the commons in matters of pleasure. Is this because our Puritan inheritance makes us view pleasure as something of a sin, and pain (that is, the pollution of advertising) as the sign of virtue?

Every new enclosure of the commons involves the infringement of somebody's personal liberty. Infringements made in the distant past are accepted because no contemporary complains of a loss. It is the newly proposed infringements that we vigorously oppose; cries of "rights" and "freedom" fill the air. But what does "freedom" mean? When men mutually agreed to pass laws against robbing, mankind became more free, not less so. Individuals locked into the logic of the commons are free only to bring on universal ruin once they see the necessity of mutual coercion, they become free to pursue other goals. I believe it was Hegel who said, "Freedom is the recognition of necessity."

The most important aspect of necessity that we must now recognize, is the necessity of abandoning the commons in breeding. No technical solution can rescue us from the misery of overpopulation. Freedom to breed will bring ruin to all. At the moment, to avoid hard decisions many of us are tempted to propagandize for conscience and responsible parenthood. The temptation must be resisted, because an appeal to independently acting consciences selects for the disappearance of all conscience in the long run, and an increase in anxiety in the short.

The only way we can preserve and nurture other and more precious freedoms is by relinquishing the freedom to breed, and that very soon. "Freedom is the recognition of necessity"—and it is the role of education to reveal to all the necessity of abandoning the freedom to breed. Only so, can we put an end to this aspect of the tragedy of the commons.

REFERENCES

1. J. B. Wiesner and H. F. York, *Sci. Amer.* **211** (No. 4), 27 (1964).
2. G. Hardin, *J. Hered.* **50**, 68 (1959); S. von Hoernor, *Science* **137**, 18 (1962).
3. J. von Neumann and 0. Morgenstern, *Theory of Games and Economic Behavior* (Princeton Univ. Press, Princeton, N.J., 1947), p.11.
4. J. H. Fremlin, *New Sci.*, No. 415 (1964), p. 285.
5. A. Smith, *The Wealth of Nations* (Modern Library, New York, 1937), p. 423.
6. W. F. Lloyd, *Two Lectures on the Checks to Population* (Oxford Univ. Press, Oxford, England, 1833), reprinted (in part) in *Population, Evolution, and Birth Control*, G. Hardin, Ed. (Freeman, San Francisco, 1964), p. 37.
7. A. N. Whitehead, *Science and the Modern World* (Mentor, New York, 1948), p. 17.
8. G. Hardin, Ed. *Population, Evolution, and Birth Control* (Freeman, San Francisco, 1964), p. 56.
9. S. McVay, *Sci. Amer.* **216** (No. 8), 13 (1966).
10. J. Fletcher, *Situation Ethics* (Westminster, Philadelphia, 1966).
11. D. Lack, *The Natural Regulation of Animal Numbers* (Clarendon Press, Oxford, 1954).
12. H. Girvetz, *From Wealth to Welfare* (Stanford Univ. Press, Stanford, Calif., 1950).
13. G. Hardin, *Perspec. Biol. Med.* **6**, 366 (1963).
14. U. Thant, *Int. Planned Parenthood News*, No. 168 (February 1968), p. 3.
15. K. Davis, *Science* **158**, 730 (1967).
16. S. Tax, Ed., *Evolution after Darwin* (Univ. of Chicago Press, Chicago, 1960), vol. 2, p. 469.
17. G. Bateson, D. D. Jackson, J. Haley, J. Weakland, *Behav. Sci.* **1**, 251 (1956).
18. P. Goodman, *New York Rev. Books* **10**(8), 22 (23 May 1968).
19. A. Comfort, *The Anxiety Makers* (Nelson, London, 1967).
20. C. Frankel, *The Case for Modern Man* (Harper, New York, 1955), p. 203.
21. J. D. Roslansky, *Genetics and the Future of Man* (Appleton-Century-Crofts, New York, 1966), p. 177.

AP ENVIRONMENTAL SCIENCE
School Year: 2020-2021
Instructor: Mrs. Cangelosi
Email: fcangelosi@tka.net

Summer Assignment #2: 30 points

Directions:

- Read the article "6,000,000,000 Consumption Machines - Environmental Aspects of Population Growth"
- Answer discussion questions 1 and 2 using complete sentences in paragraph form. Do not write the question. Minimum length - 2 pages typed. 11pt font

Discussion Questions:

1. Summarize the consequence of human population growth on the following: (24 pts)
Water; Forest; Air; Soil; Ocean; Animals

2. Discuss *at least* two scenarios depicted in this article that relate to the "Tragedy of the Commons". (6 pts)

6,000,000,000 Consumption Machines - Environmental Aspects of Population Growth
International Wildlife, Sept-Oct, 1999

As Earth's human population surges to new records, what will be the impacts on natural systems?
SOMETIME on October 12, 1999 -- most likely in China or India, according to demographic probabilities -- the Earth's six billionth human will be born.

As a consumer of water and food, forest products and clean air, animals and the ocean's bounty, this newborn will make but a tiny dent on natural resources during its sojourn on the planet. But put Baby Six Billion together with all the other human consumption machines already here, and alarm bells go off.

Can Earth's natural resources and ecological systems withstand the additive impact of this latest member of our species? Worse yet, what will happen in the year 2025, when Baby Eight Billion is projected to be born?

If this latest addition to the human family arrives in a developed country -- say, the United States -- he or she will automatically be in the top 20 percent of the human race, at least in terms of good housing, potable water, proper sanitation, a high school or college education, sound medical care, jobs, disposable income and leisure time. But Baby Six Billion will also be part of an elite that consumes in record numbers. In all, 270 million Americans use up nearly 10 billion metric tons of materials a year, 30 percent of the planet's total. And the world's one billion richest people -- which also include Europeans and Japanese, among others -- consume 80 percent of the Earth's resources.

If, on the other hand, Baby Six Billion is indeed born in the Third World, where three-quarters of humanity is already concentrated, he or she stands a good chance of being thrown into misery and deprivation. One-third of Earth's people -- two billion of them -- already subsist on just $2 a day or less. Half of all people on Earth have improper sanitation facilities. A quarter has no access to clean water. A third lives in substandard housing, many in tin-roofed shacks with dirt floors. A sixth will never learn to read, and 30 percent who enter the global workforce will never get adequate job opportunities. The other five billion people on Earth make do with just 20 percent of the planet's resources.

Rising expectations and the inevitable quest for improved living conditions in the Third World are likely to exacerbate this assault on resources. The average American consumes 37 metric tons of fuels, metals, minerals, food and forest products each year. By contrast, the average Indian consumes less than one metric ton. According to the United Nations, if the entire population of the Earth were to have the same level of consumption as the average American or West European, it would take three Planet Earths to supply the necessary resources.

Regardless of where Baby Six Billion is born, he or she will contribute to the relentless collective consumption that continues to devour global resources at rates most experts say are non-sustainable. And in the process, the human newcomer -- along with his 5,999,999,999 companions -- will produce enormous quantities of waste.

Whether Earth has the ability to absorb more people and provide for their ever-growing needs is not a closed question. Some technocrats have argued that the Earth's greatest resource is the innate capacity of human beings to invent or engineer their way out of population and resource crises. If that is so; however, human ingenuity is not keeping pace with human consumption as measured in the degradation of virtually every natural system -- from the chilly North Atlantic with its vital fisheries to the steamy rain forests of Amazonia with their incomparable array of plants and animals.

When all is said and done, human activities caused by population growth and consumption patterns are taking a heavy toll on our planet's life-support systems -- and on Earth's other species, which are disappearing at record rates as human numbers rise. The following report looks at the collective effect of six billion consumption machines on six aspects of the natural world. It is a grim picture, with only flashes of hope.

Don Hinrichsen is an environmental reporter who specializes in covering the developing world. For the last 12 years, he has also been a consultant on population for the United Nations system, principally the UN Population

Fund. His analysis is based on an in-depth review of available sources, including government agencies, environmental groups, think tanks, international entities and individual experts.

WATER - Squandering the Planet's Lifeblood

WATER IS THE LIQUID of life. Without it, the blue planet would be a dead and barren wasteland. Fresh water is also the most finite of Earth's resources. There is no more water on Earth now than there was 2,000 years ago when the human population was less than 3 percent of its current size. But population growth and rising use have put the squeeze on available resources.

Today, 31 countries with a collective population of half a billion people are experiencing chronic water shortages for all or part of the year. But within just 25 years, that figure will explode to 50 countries and 3 billion people -- 35 percent of all the people projected to be living on Earth in 2025.

Experts cite two reasons for this drastic increase: population growth plus the increasing demands of agriculture, industry and urban areas. During this century, the world's population has tripled, while the amount of water withdrawn from the planet's finite total has increased by more than six times. Since 1940, annual use of water has grown twice as fast as global population.

While population growth and escalating consumption patterns mean there is less water available per person, water resources are increasingly fouled with all manner of wastes. These include raw sewage and garbage from urban areas, toxic industrial effluents and such agricultural runoffs as fertilizers, pesticides and animal wastes. The UN Food and Agriculture Organization (FAO) estimates that each year roughly 450 cubic kilometers of wastewater -- an amount equal to the entire renewable freshwater resources available to Malaysia on a yearly basis -- are discharged into rivers, streams and lakes. More than 13 times that amount of clean water is required just to dilute and transport this dirty water. If current trends continue, the FAO projects, the world's entire river flow will be needed just for pollution transport and dilution by the middle of the twenty-first century.

As a global average, agriculture accounts for the lion's share (70 percent) of water taken for human use. Farming also accounts for the largest amount (70 percent in the U.S. and Europe, 50 to 60 percent in developing countries) of pollution to surface and ground waters. Disease carried by dirty water kills more than 12 million people a year, mostly women and children. And nearly all these deaths take place in the Third World.

There is another sinister side to the water crisis. As of 1996, the world's human population was expropriating 54 percent of all the accessible fresh water contained in rivers, lakes and underground aquifers. By 2025, population growth alone will push this figure to 70 percent. As humankind withdraws more and more water to satisfy its unquenchable thirst, less is available to maintain vital wetlands, like the Everglades in Florida.

The wholesale loss and degradation of life-giving riverine, lake and wetland habitats translates to a dramatic decline in populations of other species. Globally, close to one-quarter of all freshwater fish species are either endangered, vulnerable or on their way to extinction. Southeast Asia's Mekong River alone reports a two-thirds drop in fish catch due to dams, deforestation and the conversion of nearly 4,000 square miles of mangrove swamps into rice paddies and fish ponds.

Caught between finite and increasingly polluted water supplies on one hand and rapidly rising demand from population growth and development on the other, many countries face uneasy choices. The World Bank warns that the lack of fresh water is likely to be one of the major factors limiting economic development in the decades to come. It is also likely to spawn wars.

Recycling Works

The successful reuse of treated urban wastewater for irrigation is on the rise. In Mexico City, wastewater irrigates and fertilizes alfalfa used for small-animal feed. In Asmara, the capital of Eritrea, it waters one-third of all vegetables grown. And in Lusaka, Zambia, one of the city's biggest squatter settlements irrigates its vegetable crops with liquid from nearby settling ponds.

FOREST - Earth's Green Lungs Begin to Fade

THE EARTH'S green mantle of forests provides humankind with multiple benefits. Forests absorb carbon dioxide and produce oxygen, regulating climate. They anchor soils and prevent erosion. They regulate water flow and protect watersheds. And they provide habitat for countless species of plants and animals. Yet over the course of the past half century, this green mantle has been reduced to tattered remnants.

Currently, about 39.5 million acres of forest, an area roughly the size of Nepal, are cut, bulldozed or burned each year. According to the World Resources Institute (WRI), an environmental think tank based in Washington, D.C., half of the world's original forest cover has been lost, with most of the destruction taking place during the last four decades. WRI reports that only one-fifth of the world's remaining forests are classified as "frontier forests" -- pristine areas that have not been disturbed or degraded by human activities.

In Europe, despite green belts and conservation areas, only a tiny patch of the continent's original forest remains, cloistered in Bialowieza National Park in southeast Poland, hard against the border with Belarus. Here 1,000-year-old linden, oak and hornbeam stand cathedral-like -- silent reminders of what has been lost irrevocably. Old-growth forests in the United States have been decimated, too; in the contiguous 48 states, 99 percent of frontier forests are gone -- an empty echo of what once was. Most experts link the loss of such forests, directly or indirectly, to human population growth and the insatiable demands of people. Lester Brown of the Washington-based Worldwatch Institute, which monitors human use of resources, reckons that 75 percent of the historical growth of population and 75 percent of the loss in global forest cover has taken place in the twentieth century. "The correlation makes sense," reasons Brown, "given the additional need for farmland, pastureland and forest products as human numbers expand. But since 1950, the advent of mass consumption of forest products has quickened the pace of deforestation."

In the Third World, conversion of forest resources to meet everyday human needs is significant. Dirk Bryant, a senior researcher at WRI, estimates that fuelwood collection and overgrazing by domestic animals are now responsible for degrading about 14 percent of the world's remaining frontier forests, nearly all of which -- disregarding northern Canada and Russia -- are found in developing countries.

But the relentless and rapidly escalating consumption of forest products by rich countries is also responsible for whittling away much of the remaining pristine forests. The use of paper and paperboard per person has nearly tripled since 1960, with the developed countries of North America, Europe and Asia accounting for most of it. North America, Europe and Japan, with just 16 percent of the global population, consume two-thirds of the world's paper and paperboard and half of its industrial wood.

Researchers at Friends of the Earth in the United Kingdom have determined that humanity's demand for forest products is already 25 percent beyond the point of sustainable consumption. What this means is that given population and income growth in the developing world and continued demand for forest products in the industrialized world, the future of the world's frontier forests and all the ecosystem benefits they provide to humankind are in jeopardy.

Sustainable Living

Increasingly, core forest areas are being set aside as sustainably exploited reserves to enable indigenous people to generate income. In Ecuador's Andes, Queche Indians gather more than 3,600 plant species for use in pharmaceuticals and traditional medicines, leading to regionwide conservation. The Queche also use forests for building materials and agro-forestry products.

AIR - Dark Skies, Changing Climates

CLEAN AIR is the life-giving resource most people take for granted. Yet increasingly, as human population spirals and consumption rises, the air we breathe is becoming both an agent of illness and the vehicle for modifying Earth's climate.

Few experts dispute the simple fact that more people means more air pollution. Even with the availability of vastly improved technologies to limit pollution, population growth translates directly into more use of energy, more cars on the road, more factories and hence more dirty urban air.

In turn, that often results in severe health problems. Today, more than one billion people suffer from dangerously high air-pollution levels. Most of those live in sprawling Third World cities where industries and power plants have few, if any, pollution controls and where traffic jams are a perpetual feature of urban life. Up to 700,000 of those people die every year from the air they breathe.

Cities such as Bangkok, Manila and Beijing are often entombed in a sickening pall spewed out from a rapidly growing fleet of vehicles and uncontrolled industrial emissions. In these cities and 17 others, air pollution -- most commonly in the form of sulfur oxides, oxides of nitrogen, carbon monoxide and ozone -- is one of the leading causes of respiratory infections and premature death. Just breathing the air in Mexico City has the same health effect as smoking three packs of cigarettes a day.

On the consumption side, the distribution of energy is uneven. Currently, the richest fifth of humanity consumes close to 60 percent of the world's energy, while the poorest fifth uses just 4 percent. The benefits of the fossil-fuel revolution, which drives industrial nations, have still not reached a full third of humanity -- the two billion people who must burn fuelwood and organic waste for heating, cooking and lighting.

The other side of the atmospheric pollution problem is climate change, often called global warming. When carbon from burning of wood, coal, oil and other fossil fuels is released into the atmosphere, it combines with oxygen to form carbon dioxide, the gas responsible for two-thirds of human-induced changes in the world's climate. Atmospheric concentrations of carbon dioxide in 1997 reached 363.6 parts per million, the highest in more than 160,000 years.

Altogether, carbon emissions are rising faster than the rate of population growth. In 1997, according to the Worldwatch Institute, global emissions of carbon totaled 6.3 billion tons. Since 1950, world carbon emissions have increased fourfold. Though western industrialized countries currently account for close to half this output, developing countries have increased their share dramatically in the past decade and are collectively responsible for 40 percent of global carbon emissions. China is now the world's second largest emitter, after the United States, with a 14 percent share.

Over the course of the next century, atmospheric concentrations are expected to double, triggering potentially devastating climatic changes on a regional and global scale. By 2100, according to the U.S. National Academy of Sciences, sea levels may rise by up to one meter, inundating vast swaths of coastal land, while average surface temperatures may increase by up to 3.5 degrees Celsius. Destabilization of the Earth's climate engine is expected to result in more intense heat waves, more severe droughts and floods, more devastating storms (tornadoes and hurricanes) and more frequent forest fires. These events, in turn, can add to the problem. The six months of extensive forest fires in Asia in 1997 and 1998 released more carbon into the atmosphere than Western Europe emits in an entire year.

Blowing in the Wind

Clean wind-generated electricity, already produced in Europe and the United States, has become increasingly competitive with fossil-fuel-fired power plants. Wind-powered generators using advanced engineering are being manufactured in Germany, Denmark, India, Spain and the United States. The electricity they generate is valued at $2 billion a year, up by 25 percent annually.

SOIL - From Bare Earth: Hunger Amid Plenty

THE WORLD'S topsoils, the "bottom line" in food production, are increasingly eroded and degraded by the demands both of large-scale mechanized agriculture and the desperate needs of subsistence farmers. We could be

entering what some experts call the "century of scarcity," as rising demand for food is paralleled by a corresponding drop in supply.

Food shortages may seem an incredulous idea to those who subscribe to the "horn of plenty" scenario of agricultural productivity. After all, since the end of World War II, food production has tripled while population has only doubled. And the daily calories available per person in the Third World have increased from an average of 1,925 in 1961 to 2,540 in 1992.

Yet the prospects are unsettling. Much of the expansion of food production since the post-war days is explained by the adoption of crop rotation, mass production, use of petroleum-based fertilizers, chemical pesticides and expanded irrigation. Since the early 1960s, the introduction of genetically superior, disease-resistant cultivated crops -- a signature part of what is known as the Green Revolution -- also contributed heavily to food-production gains. But many of these successes have been accompanied by a downside -- widespread land abuse and inappropriate agricultural policies, including $228 billion worth of subsidies spent on price supports and outright payments.

The gains in food output are not universal either: There is still widespread hunger in the midst of this plenty. The world has 840 million chronically malnourished people, mostly women and children, while an additional one billion suffer from protein malnutrition. Also, despite slower rates of population growth over the past decade, grain supplies per capita have actually fallen worldwide.

Declines in food production are particularly critical in many poor countries. Between 1985 and 1995, food production lagged behind population growth in 64 out of 105 developing countries. Africa, where food production per person fell in 31 out of 46 nations, fared the worst of all. It now produces nearly 30 percent less food per person than it did in 1970.

The change in direction in food availability in these areas is due primarily to two trends. On the one hand, rapid population growth and changing diets have increased demand. On the other, higher population densities in traditional agricultural areas, fragmentation of small farmsteads, poor land management and inappropriate agricultural and economic policies have suppressed supply.

Together, population growth, rapid urbanization and land degradation have also combined to reduce the amount of food-producing land available for each person on Earth. In developing countries as a whole, the average amount of arable land per person fell from about 0.3 hectares (a hectare equals 2.47 acres) in 1961 to less than 0.2 hectares in 1992.

On top of these alarming developments, nearly 2 billion hectares of crop and grazing land -- an area larger than the United States and Mexico combined -- suffer from moderate to severe soil degradation. The main causes are soil erosion, loss of nutrients, damage from inappropriate farming practices (including poorly built irrigation systems) and the misuse of agricultural chemicals. In the Philippines, for instance, nearly one-quarter of all cropland has been severely degraded.

According to WRI projections, by 2025 about 3 billion people, 35 percent of the global population, will live in land-short countries, with less than 0.07 hectares of fertile land per person. That is roughly the size of two tennis courts.

Increasing Yields

Farmers in 400 villages in Burkina Faso, one of the poorest countries in West Africa, have hiked farm yields by 50 percent. They did so thanks to the rediscovery of an ancient -- and simple -- technique for using scarce water more efficiently. To slow runoff and spread the water across a wider area, they place long lines of stones along the contours of gently sloping ground.

OCEANS - Trouble in Earth's Liquid Heart

OCEANS, where life first evolved 3.5 billion years ago, cover 70 percent of the globe's surface. They wrap around the planet like an insulating blanket, making life possible on Earth today.

Oceans are the engines that drive the climate, defining weather and storing huge quantities of solar energy. They also make up the liquid heart of the planetary hydrological cycle, enabling roughly 430,000 cubic kilometers of water to evaporate every year.

But even this vast watery world is coming under increasing pressure from human activities. Just over half of humanity -- some 3.2 billion people, according to some estimates -- live and work within 120 miles of a sea coast, on just 10 percent of the Earth's land area. Two-thirds live within 250 miles of a coast.

These mounting human numbers and the development that follows in their wake have taken a grim toll on ocean resources nearby. Half the world's coastal wetlands, including salt marshes, for instance, have disappeared. And close to 70 percent of the world's beaches are eroding at rapid rates because of human impacts.

Coastal ecosystems, valuable because they function as nurseries for fish and other sea life, have been especially hard hit. Over the past century alone, 25 million hectares of mangrove forests -- multi-rooted trees on the edge of the sea -- have been destroyed or grossly degraded. Seagrass beds -- underwater meadows in coastal shallows -- have fared little better and are in retreat near virtually all inhabited coastal areas.

Coral reefs, the rain forests of the sea with perhaps 1 million species, are being pillaged as well. They are poisoned by sewage outfalls, overfished, dynamited, pummeled by ship's anchors, broken by recreational divers and bleached by unseasonally warm temperatures. Of the world's 230,000 square miles of reef-building corals, 60 percent could be lost within 40 years, marine biologists fear. Over 80 percent of the reefs in Southeast Asia alone are in peril.

One of the biggest threats to the integrity of ocean ecosystems is directly attributable to people and their insatiable demand for protein: the relentless hunt for fish. Of the world's 15 major oceanic fisheries, 11 are in decline. The catch of Atlantic cod has dropped 70 percent since 1970, while bluefin tuna stocks have declined by 80 percent over the same period.

A fivefold growth in seafood consumption since 1950 has pushed these and other fisheries to the brink and beyond. Between 1991 and 1995 the world's commercial fleets hauled in, on average, 84 million tons of seafood a year. Since seafood provides close to 20 percent of the world's total animal protein intake -- up to 90 percent in the South Pacific and parts of Southeast Asia -- the decline in fish catches is eroding food security for a number of poor countries in the tropics.

The overcapacity of the world's fishing fleets has itself become a threat to the integrity of ocean ecosystems. Currently, 5.8 million square miles of ocean bottom are trawled each year, the marine equivalent of strip-mining. Since bottom trawls are indiscriminate harvesters of marine life, the by-catch from these operations constitutes a horrendous waste of potential food. Every year, 10 pounds of fish and shellfish are discarded for every person on Earth -- up to 40 million tons.

In too many places, the sea has also become a dumping ground for oil and a giant cesspool to collect the runoff of poisons from inland sources. Each year, for instance, effluents flowing from the Mississippi River system leave a lifeless dead zone 30 miles out into the Gulf of Mexico.

Reclaiming Mangroves

On the Philippine island of Negros, fisherman Wilson Vailocos talked his neighbors into planting mangrove trees along the coast to stabilize eroded shoreline and provide feeding and nursery areas for valuable fish. He also formed seagoing patrols to enforce a ban on dynamite and cyanide fishing. Result: Mangroves have reclaimed 100 hectares of land, and the illegal fishing has been eliminated.

ANIMALS - Plundering the Planet's Species

HUMAN LIFE cannot exist in the absence of complicated interactions of millions of species in biological systems. Yet we live in a period of the greatest loss of plant and animal species since the mega-extinctions of the Jurassic Period 65 million years ago.

Every year over the course of the coming decades, 50,000 plant and animal species are likely to disappear, ecologists warn. The percentage of birds, mammals, fish, reptiles and amphibians threatened with extinction is now in double digits, and the loss of insects and microorganisms is incalculable. Overall, human-induced habitat loss, killing by bushmeat hunters in the Tropics, and the introduction of nonnative species, among other problems, has conspired to change the lineup of species on Earth.

Loss of biodiversity is not limited to wildlife. Since 1900, about three-quarters of the genetic diversity of agricultural crops have also disappeared, according to FAO estimates, along with half the wild gene pool upon which domestic cattle are dependent for improving their resistance to diseases, pests and changing environmental conditions.

Increasing population density and pressure for faster but unmanaged economic development are largely to blame. In a study of 50 countries in Asia and Africa, the United Nations Population Fund found that the loss of natural habitat was greatest in high-density areas and least in low-density areas. In the 10 countries that had lost the most habitat, population density averaged close to 200 people per square kilometer. In the 10 countries that had lost the least amount of habitat, the population density averaged just 29 people per square kilometer.

The outlook is particularly bleak in some of the most biologically rich countries of the Third World, where population growth and unsustainable exploitation of natural resources is savaging habitat in "biodiversity hotspots" -- ecosystems with a superabundance of plant and animal species. So far, 24 of these hotspots containing half the planet's land species have been identified. Overall, five of the six most biologically diverse countries could see more than two-thirds of their original habitat destroyed or grossly degraded by the middle of the next century.

Meantime, the world's last great expanses of pristine, mostly uninhabited tropical forests now face imminent destruction. These large tracts of land -- in the Guayana Shield region of northern South America, Amazonia, Africa's Congo and the island of New Guinea -- are prime targets for logging. Together, they are about the size of the state of Alaska.

In other areas, the introduction of nonnative, or exotic, species contributes to extinction woes. Hawaii's native fauna and flora have been decimated by species brought in, deliberately or by accident, by people. On the U.S. mainland, exotics have been implicated in close to 70 percent of all fish extinctions this century. In Europe, much of the Black Sea's fauna has been eliminated by a combination of overfishing, pollution and exotics. Its commercially valuable fish species have declined from 26 to 5 in a decade.

On top of all that, an ominous new term has been added recently to the biologists' lexicon of threats to animals: "defaunation," also referred to as "the empty forest." From Laos to Congo, Brazil to Madagascar, impoverished people desperate to put food in the pot are killing whatever moves. Now, vast areas of tropical forest have been scoured nearly clean by hunters of bushmeat. For the first time, there are large areas of available habitat with few birds or mammals to live in them.

Saving Europe's Wolf

Thanks to the tireless work of countless wildlife groups, the gray wolf has expanded its range in Europe. In a stunning comeback, it is recolonizing Germany, Austria, France and Switzerland. In Slovakia, the WOLF Forest Protection Movement aims to have 52 WOLF groups, at least one in each of 42 major watersheds threatened by large-scale logging.