**COMMITTEE VII**
Global 2000 Revisited: Re-assessing
Man's Impact In Spaceship Earth

DRAFT - 10/15/86
For Conference Distribution Only

# KEYNOTE ADDRESS:
# ALTERNATIVE PERSPECTIVES ON THE EARTH'S PROSPECTS
[The Global 2,000 Report (GTR) vs The Resourceful Earth (TRE)]

by

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The Fifteenth International Conference on the Unity of the Sciences
Washington, D.C. November 27-30, 1986

10/2/86

# Alternative Perspectives on the Earth's Prospects

(The Global 2,000 Report (GTR) vs. The Resourceful Earth (TRE))

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Keynote Paper: Committee VII of ICUS XV

# ALTERNATIVE PERSPECTIVES ON THE EARTH'S PROSPECTS

## (The Global 2,000 Report (GTR) vs. The Resourceful Earth (TRE)

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## I Introduction

There are two alternative perspectives about the Earth's physical prospects. The first perspective is very familiar -- I call it the "scarcity perspective" or the "doomsday perspective". It is most authoritatively represented by the official document of the U.S. government, The Global 2,000 Report (submitted to the President by the Department of State and the Council on Environmental Quality in 1980). The current round of great public attention to this perspective began with the Report to the Club of Rome entitled The Limits to Growth by Jay Forrester. And there is now a group of organizations called The Global Tomorrow Coalition engaged in putting forward this perspective.

The best way to evaluate this perspective is to ask what is an opposite view of the world. This paper will show why the opposite view is correct -- and why therefore the doomsday perspective should be completely rejected. (Which, of course, is not to deny that doomsdayers sometimes present true facts and real tasks requiring attention.)

The major part of the paper will be a presentation of such an opposite perspective, which I call the "Passage to a Human World Perspective" -- a perspective which is supported by books such as The Resourceful Earth, World Economic Development, The Ultimate Resource, and The Next 200 Years, all written or edited

by Herman Kahn and Julian Simon.

## II The Scarcity Perspective

The two outlines on the next page are an efficient way to summarize the scarcity perspective.

The general sense of the situation expressed in Figure 1 is the opposite of the truth. And all of the specific propositions in Figure 2 are incorrect. But to get to the heart of the doomsday perspective we must go beyond refuting some specific propositions, because the scarcity perspective grows out of a real human concern. I want to address that underlying concern, not just expressions that it takes. So I use the phrase "scarcity perspective" to cover all the ideas and arguments that grow out of that concern, which is felt in one way or another by a great many people. It is the fear or belief that modern society is riding for a fall -- that our way of life uses so much material and creates so much waste, and our population is growing so fast, that sooner or later we have to run into dangerous shortages, or hopelessly pollute our environment. After all the Earth is finite.

Another form of the same concern is the common idea that somehow the question of whether the rapidly increasing billions of people in the third world can catch up depends on whether there are enough raw materials left for them at reasonable prices.

Another form of the scarcity perspective is the feeling that it is somehow unfair that the U.S. should be using a quarter of all the raw materials taken out of the Earth, that we are taking

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Figure 1

THE DOOMSDAY PERSPECTIVE (TONE)

THE WORLD WILL BE:

- MORE CROWDED
- MORE POLLUTED
- LESS STABLE
- MORE VULNERABLE

PEOPLE WILL BE POORER

LIFE WILL BE MORE PRECARIOUS

THREATS TO THE FUTURE OF MANKIND

POPULATION APPROACHING CARRYING CAPACITY OF THE EARTH

BETTER PROJECTIONS WOULD SHOW MORE INTENSIFYING STRESS

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Figure 2

"THE DOOMSDAY VIEW" (PROPOSITIONS)*

1. THE OVERALL PHYSICAL CONDITION OF THE WORLD IS GETTING WORSE AS MORE AND MORE PEOPLE USE IT MORE AND MORE INTENSELY.

   - RAW MATERIAL SCARCITY
   - POLLUTION
   - DANGERS TO HEALTH (CHEMICALS, NUCLEAR WASTES, ETC.)

2. AS RAW MATERIALS ARE CONSUMED AT EVER-INCREASING RATES, THE WORLD IS EVENTUALLY DOOMED TO HAVE GREAT RAW MATERIAL SCARCITY PROBLEMS (PERHAPS COMBINED WITH WORSENING POLLUTION).

3. CURRENT WORLD POPULATION TRENDS THREATEN TO EXCEED THE EARTH'S CARRYING CAPACITY IN THE NEXT FEW CENTURIES. IF THEY CONTINUE THERE WOULD BE TEN TIMES THE CURRENT POPULATION IN ONLY A FEW CENTURIES AND THERE WOULD BE A SHORTAGE OF LIVING SPACE.

4. ALREADY THE AMOUNT OF ARABLE LAND IS SHRINKING AND LOSING QUALITY AS FARMLAND IS CONVERTED TO URBAN USE AND TO ROADS, AND AS TOPSOIL IS ERODED.

5. THEREFORE, THE BASIC LONG TERM PROBLEM FOR MANKIND WILL BE HOW TO ADJUST TO INCREASING SCARCITY.

*Correct statements are shown on the next page.

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* Here are the facts that refute the Doomsday Propositions

1. The overall physical condition of the world is not getting worse. Obviously some things are getting worse, but the following indicators seem to be the most significant, and they show the world getting better for people:

a) World-wide life-expectancy is increasing. (also in almost all countries except the Soviet Union)
b) Amount of economic resources available each year per person is increasing. (Worldwide and most countries)
c) Per capita food production is increasing.
d) Famine deaths are decreasing.
e) Most raw material costs -- with possible exception of fuel and forest products -- are not increasing.
f) In at least some wealthy countries overall pollution levels are declining -- which suggests that as other countries become wealthy their pollution levels will also be reduced.

The world is not getting more crowded -- except in the meaningless sense that Greenland would be more crowded if its population doubled. There is no measure of "crowding" if the word implies harm or discomfort. Usually the amount of living space available to a person depends on his or her income and preference. Therefore as real incomes rise, any increase in crowding will be that preferred by people.

Increasing resources -- and knowledge -- means reduced vulnerability.

2. It may be **possible** that the world will have raw material scarcity problems; but there is no evidence that it is inevitable, and the best evidence is that it will not happen at all (E.g., Scarcity and Growth, Barnett & Morse, RFF, Washington, D.C. 1963.) Of course, some raw materials may become scarce, but not enough to be troubling to human life.

3. All demographers agree that current population trends are in the direction of something like a leveling off of world population below 20 billion people. If "carrying capacity", is a meaningful concept, 20 billion is way below it.

4. Standard U.N. and other figures are that arable land is increasing (net of losses).

5. Since the share of effort and resources used to get raw materials (and protect against pollution) is declining, and probably will continue to do so, adjusting to scarcity will not be a major problem. The major problems the world will face are the human problems of adjusting to wealth and power. (And the major physical problems will concern economic organization, not raw material supply.)

more than our share. This charge of "greediness" can relate either to poor countries or to future generations. But, obviously it only has meaning if the result of our taking is that there isn't enough left for others.

How do you get at something as broad as the scarcity perspective? People rarely say things like, "I think there will be a big scarcity problem in 100 years because ...." They don't think specifically about long run scarcity because it is too difficult and it doesn't seem relevent to any practical issues. They just assume that the scarcity perspective is correct. Few people even realize that the scarcity perspective is a particular idea, that there is an alternative to it, and that therefore it might be wrong.

The scarcity perspective is as natural as breathing, so people would say that they have never thought about long run raw material supply problems. But, in effect, they have. Anyone who has any of the concerns I quoted above is acting as if he thought about the question of whether there will be raw material scarcity problems in the future and reached the conclusion, "yes, sooner or later there will be a problem." (Why else would it be unfair for us to take all the raw materials we want, if the supply remaining for others was not reduced?)

Of course if people are specific enough to point to a particular problem and a particular date they can be answered specifically, and shown why that particular scarcity fear is unrealistic. This has happened repeatedly, and many specific predictions have come due and been proven wrong by events. The problem is that many people observing, for example, a debate

about whether GTR is correct, have the following kind of reaction: (from a Washington Post report on meetings where the GTR was strongly criticized) "a consultant to Earthwatch acknowledged that the original GTR projections may turn out to be wrong but said, 'that is not the point. The idea was to call attention to the fact that we are destroying our habitat. That is still true.'"*

That is the perspective I am trying to define and that I will show is wrong. It is not only that the particular argument in GTR or The Limits to Growth or The Population Bomb (a book by Paul Ehrlich) is wrong. (Although the particular arguments and conclusions in these books are wrong, as wrong as the book Famine--1975 which was published in 1967 and sold tens of thousands of copies.)

The important thing is that the whole perspective is wrong. There isn't anything there. We are not destroying our habitat. (We might, but we don't have to.) And we don't have to sacrifice our freedom or our standard of living to avoid destroying our habitat. We don't even have to make drastic changes in the way we make decisions. Of course there are practical problems of how to grow more food, enable poor countries to get rich enough so

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* Sometimes people get angry at one for criticizing studies like GTR. They say, in effect, "you are quibbling over details and trying to prevent people from facing up to one of the world's greatest problems. By arguing about the specific numbers in these studies you are giving people an excuse for continuing their selfish and dangerously wasteful practises. It is infamous to treat such studies like academic exercises; if people don't recognize and do something quickly about the danger of exploding world population and the ecological limits of Spaceship Earth we may pass a point of no return."

that their people can live decent lives, and many other urgent tasks. But these problems have essentially no connection with long run scarcity or the finiteness of the Earth.

To really deal with the human concern that underlies the scarcity perspective I need to show that there are enough raw materials -- and enough places to dispose of waste without polluting the environment -- for ever; not just for a few centuries or a few thousand years. The best way to really get at the heart of the scarcity perspective -- not just one expression of it -- is to show that there is no reason to worry that mankind's safety or standard of living need ever be threatened by resource shortages or pollution problems. (Of course it is not necessary to say that there are no dangers and problems to reject the scarcity perspective. The fact that mankind faces some dangers and problems doesn't invalidate the statement that there is essentially no truth to the scarcity perspective.)

Such an extreme claim -- that we can be confident that there are enough resources for ever -- is necessary because if I just show that we have enough for a thousand years people will say, "How can you be sure? Maybe your calculations aren't exactly right and there is only enough for 500 years, or even a hundred. And anyway, if we are going to get into trouble in a thousand years maybe we have a responsibility to begin to move at least a little way in the direction that will need to be taken eventually." It seems somehow shabby and second-class to be going against history, against the long run imperative facing mankind. It seems selfish and short-sighted to try to get away

with what we can take, and leave the ultimate clean-up job to our remote descendants, just because they aren't here to complain or to vote.

That is why I am going to attempt the seemingly silly task of answering the question, "Do we have enough for ever?" (Of course I don't really take care of "for ever". For example, I don't deal with the question of geological changes, or the sun becoming a red giant. These are matters of millions or billions of years. I am only concerned with human history which so far has been measured in tens of thousands of years.)

But before discussing the "technical problems" of providing resources and protecting ourselves from pollution, we should first take a look at what is happening in history -- because it is a dramatic story that provides the essential context.

## III The Passage to a Human World Perspective

Until recently, asking the basic questions about human life on Earth always produced the same answers; there was surprisingly little news. Life expectancy scarcely changed from the first men until the last century, when it was still less than 30 (having risen only a few years). This single grim statistic tells much about the fundamental nature of people's life experience. It says that few children grow up with two parents. That most adolescents have more brothers and sisters dead than alive. That the person who gets to know his grandchildren is rare indeed. So human life was always full of the death of loved ones, and the likelihood of dying young.

Throughout human history most people produced what they consumed by monotonous, arduous, outdoor work, and lived in cramped and dirty surroundings. Most of them spent their entire lives not far from where they were born and spoke to no more than a few hundred people before they died -- even the rare ones who lived a long life. They were at the mercy of powerful forces which they did not understand. Violence was common in their lives. And most of the time their thoughts were about the unpleasant side of nature: dirt, disease, and death.

By 1800 people had learned to create large complex societies; a small minority had learned to read and write (an accomplishment that affected many others); and many people had come to believe in God. But when confronted with a realistic description of the nasty details of the way all the ordinary people actually lived as recently as the last century, most of us would exclaim "they lived like animals".

This is too extreme. People have always been significantly different from animals. And during our long history we have produced great human creations and achievements which should still give us pride. But, compared to the human life we experience here today, the human life of the past -- or of parts of the poorest countries today, indeed of almost everyone who has ever been born -- seems so different that one can easily think of it as more like the lives of animals than like the human life we know.

But now 1/4 of the people live modern wealthy lives, living nearly their full life span. In the wealthy countries few people experience much death in their family, and most people know both

their grandparents and their grandchildren.

In the modern part of the world people are doing completely different things than they used to do. Most of their thoughts no longer are about the unpleasant aspects of nature, they are about man's creations: science, art, politics, commerce, bureaucracy, entertainment, and, sadly, crime and war. Nature is primarily something to protect and enjoy. Sometimes it is a disturbance, but only rarely is it a serious threat.

Ordinary people in the modern parts of the world know something of their own and the world's history. From the media they know something of the other people who share the Earth with them. Sometime during their life they can go to see almost any place they want. They have a reasonable degree of knowledge of the basic facts about nature. And their lives are filled with choices: where should they live? what kind of work should they do? The character and quality of most people's lives depend on the choices they make. In brief, most of these people live the kinds of lives we are familiar with.

No other word as aptly describes the character of the new world into which we are passing as the word "human". The new features of this world are being created by people. In this new world the most basic fact of life -- how much of it each person has -- will be determined by the genes of our human species, not by external natural forces that cut human life short. Humans will be plentiful, and their lives will be the kind of lives that we think of as normal human lives -- concerned mostly with human creations, not with a constant struggle against nature. Formerly

nature dominated man - but not completely; after we finish our current brief passage man will dominate nature - but not completely.

We must still use the future tense to speak of the "human world", because it is not yet true that almost all people in the world live in what we call "human conditions". But we are well on our way to a human world and, since many people have already arrived, there are samples of this world that we can see now. We can get a feel for what a human world might be like by looking at the lives of the people in countries which have already crossed the threshold from poverty to wealth.

Despite the inevitable uncertainties about the future, already we can see that in the "wink of an eye" (i.e., a few centuries) the world is being changed more drastically than it had been changed in all human history. We are living in the middle of that wink. We can see examples of what life will be like in the future, and we can still see examples of what all human life was like in the past. We live today just about at the middle of a period of only a few hundred years, during which mankind is changing the world as it has never been changed before, into the way it will probably be from now on.

This perspective can help us to balance the normal static, snapshot, view of the world with a broader understanding. For example, we are often told that the world is divided into rich countries and poor countries. This is a little like describing a family as being divided into little people who have no money and have to go to bed at 9 o'clock and big people who are allowed to drive the car and stay out late. The big people were once

little, and the little ones will become big.

In a family the current arrangements don't mean nearly as much as a sense of the process that the family group is going through. And since adults are so familiar with the pattern of development and family life, most of us don't usually see families as snapshots, we see them in relation to the pattern of the generations. (Of course the ten-year-old, lacking the perspective that comes from experience, sees things differently. She is much more aware of the "injustice" of the moment, and the moment seems much longer.)

If we look at the world with the kind of dynamic, historic, perspective with which we look at a family, we would give a more realistic description by saying, "The world is passing from poor to rich. All countries were poor, some countries are already rich, others are nearly there, and others still have farther to go." Because we are now in the middle of the development process that is responsible for our passage some countries are now widely separated from others. And since we are barely conscious of the process, the current distance between countries seems permanent, and therefore highly unfair and immoral. But to have a reasonable perspective on the moral question, the world, like a family, should also be seen as a dynamic process in which today is only a long moment.

The confident statement that we are creating a human world sounds optimistic and arrogant. To see why it isn't, two points need to be emphasized. First, although we can be confident that the world will be **human**, we cannot know whether it will be

better. We humans have amply demonstrated our power to do evil and create unhappiness. Human domination of the world is a challenge not a seal of success. Change is not necessarily progress. The prediction that we are making a human world is a realistic description, not an optimistic hope. (And some people will feel that it is a profoundly pessimistic prediction.)

The second point to emphasize is that the word "human" is not used here in the sense of being the opposite of God. God created people as much as He created the rest of nature. While man is special, man is also part of that nature. There is no reason not to think of man's creations as part of the work of God. There is no reason one has to think that people, by changing the world from nature-dominated to human-dominated, are denying or challenging God - rather than carrying out God's will.

How do we know that the rest of the world will also become modern and wealthy? Because we can recognize the powerful process that has been shaping events, and see that that process is still working, and that there is no reason for it to stop now. So it is not very bold to predict that the process will be completed. It is as if a thrown ball were in mid-flight -- no one would hesitate to predict where the ball is going. This paper describes a process now dominating history which is almost as clear as the path of a thrown ball.

Of course there can be no guarantees of the future. Just as a ball can be knocked off-course, so the process now bearing us towards a human world could come to an abrupt end.

This approach of predicting the future by trying to understand the processes now at work is very different from a

crude extrapolation of trends. If I were merely extrapolating trends I would have to say that the ball that is thrown upward would continue upward forever. But if I understand the forces working on the ball as it flies through the air I can use its path in the past to predict its path in the future, even though the direction will change.

The process that is working now to build a human world is the spread of understanding of how to create wealth.

The term "wealth" refers to economic resources, which can be physical, like machines or houses; or they can be financial, like stocks and bonds; and some are even less tangible, like education or leisure. The idea of economic resources (or wealth) is so broad that it is hard to realize how much is covered by such a simple phrase, everything from a gigantic steam shovel to a computer program, from an hours' time to a house at the beach. "Poverty" means "the lack of things that could be bought with money".

About two centuries ago some societies began to learn how to increase the productivity of human work and thus to become wealthier and wealthier. Since then the first societies to learn have continued to apply what they had learned, and continued to learn more, so that their productivity continued to grow and their wealth accumulated. Also, one after the other, other nations have begun to learn how to steadily increase productivity. Some are doing it fast and catching up; others are going more slowly. Some haven't started yet and others have started and then fallen back. But all nations are going along

essentially the same path, starting from poverty, learning gradually to make the changes necessary to be more productive, accumulating wealth, and adjusting painfully to the changes.

Until about 100 years ago there were no wealthy societies. Today 1/4 of the people of the world live in wealthy societies. (A wealthy society is one where most people have enough resources to live decent human lives -- say, at least $3,000 per capita.) Because one can understand the process by which this tremendous amount of wealth was produced, one can have great confidence that the much greater amount of wealth required in the future will also be produced.

In about a century -- or perhaps two -- the great majority of people will live in countries that have crossed the threshold from traditional poverty to wealth that is sufficient to provide human lives for their people. (Statements here about the whole world do not include the non-wealthy communist countries -- 80% of the population of which is Chinese -- because I do not wish to make any predictions about their future.) No one knows how much further the wealth accumulation process will go after that, or what patterns it will follow.

Figures 3 & 4, at the top of the next page, give a quantitative description of the passage to a human world.

**Ideas vs. Things**

Two different perceptions about the nature of productive wealth are possible. One perception is the old-fashioned and obvious one: wealth is **things** like fertile land, rich oil deposits, and large stocks of gold. The alternative perception, which is the modern view of productive wealth, is that wealth is

Figure 3

**Some Catchy Numbers to Describe the Passage to a Human World**

| | BEFORE THE PASSAGE (1780) | NOW (1980) | AFTER THE PASSAGE (2180?) |
|---|---|---|---|
| Gross World Product (billions of 1980 $) | $200 | $10,000 | $250,000 |
| World Population (millions) | 800 | 4,000 | 10,000 |
| Average Income (GWP/person, 1980 $) | $250 | $2,500 | $25,000 |
| Life Expectancy (worldwide) | 30 years | 60 years | 80 years |

Figure 4

**Comparison of the Ammounts of Change**

| | 1780 to 1980 | 1980 to 2180(?) |
|---|---|---|
| **Gross World Product** grows: | 2% per year | 1.6% per year (?) |
| that is, overall it: | multiplies by 50 | multiplies by 25 |
| **World Population** grows: | .8% per year | .5% per year (?) |
| that is, overall it: | multiplies by 5 | multiplies by 2.5 |
| **Average Income** grows: | 1.2% per year | 1.2% per year (?) |
| that is, overall it: | multiplies by 10 | multiplies by 10 |
| **Life Expectancy** grows: | .35% per year | .14% per year (?) |
| that is, overall it: | doubles | grows by 30% |

mostly **intangibles**, for example, the characteristics of a people, such as their culture and their education, that enable them to create wealth gradually from whatever things they have. In a

word, the modern view is that most productive wealth is not "rocks" but "ideas".

Look at which countries have been most economically successful since WWII. The outstanding performers have included Japan, S. Korea, and Singapore, a large, a medium, and a small country all relatively poor in natural resources, all with large numbers of people compared to their arable land. None of these countries have done well because of their natural resources. Neither has Holland, Denmark, Switzerland, and many other countries.

On the other hand, other countries with great natural wealth, such as the Sudan, Zaire, or Argentina, have not grown at all well and are relatively poor.

Much of the "edifice of error" which blocks our view of the real world is built on the unexamined, old-fashioned, perception of wealth as "things". This out-dated perception has many important implications. If wealth is "things" it is natural to wonder whether more can be created. Where can they come from except from other things? Any thing can only belong to one country at a time. If wealth comes from things it is natural to think that the poor can only get wealthy if they get some things from rich countries. And the suspicion is very easy that rich countries' wealth came from taking things that somehow belonged to, or should have gone to, poor countries. (After all, the countries of the world used to be much more equal.) All in all, the old-fashioned perception of the nature of wealth leads easily to a paranoid view of the world, full of fears and pessimism.

For people in rich countries the old-fashioned perception can also easily lead to feelings of guilt because our things seem to be what others need.

Of course seeing wealth as primarily coming from things also leads to the fear that resource scarcity will prevent wealth from spreading to the rest of the world. The next section of the paper will show why this fear is unrealistic.

The modern perception of wealth, which sees it as mostly coming from ideas, suggests that wealth is unlimited, that it can be created everywhere at the same time, that our wealth doesn't conflict with others' wealth but is more likely to add to it, and other very nice, and mostly correct, ideas.

The most significant implication of seeing that wealth comes from ideas is that **a nation's path to wealth is primarily a "national learning experience".** (Of course words like "ideas" and "learning" are intended as metaphors standing for a very broad range of activities.)

"National learning" is not primarily a matter of technical information. Social and cultural change is a much more critical part of the national learning experience than acquiring information and technology. Economic growth comes from people learning to work better, but many people are not really free to work better without gradual and often subtle changes in their society. The culture that admires truth and effectiveness, at least at work, will produce more than the culture that prefers observance of tradional forms and cares little about truth and effectiveness.

Most of the ideas that produce higher productivity and thus

more wealth are not brilliant or dramatic. Most are barely noticeable. Maybe the typical example to keep in mind is the shipping clerk who figures out how to stack the boxes in the storeroom in a different way so that he can handle more orders. The result is more output with the same input. That is what economic growth is all about. That is a good example to keep in mind also because it illustrates that motivation is likely to be a big influence on productivity. In fact the rate at which new technology increases productivity is much less determined by the amount and quality of new technology developed in the laboratories than it is by the attitudes and relationships in the organizations that can use the new technology, and on the degree of competitive pressure that they face.

Social and cultural change are an inevitable result of increasing wealth, and they are also necessary in order to be able to become more productive and thus wealthier. Such change is the most painful part of the process.

Let's think a minute about why the United States is so wealthy. 150 years ago, when Abraham Lincoln was a young man, this was a poor country. Of course, the land had more gold and coal and iron and oil and top soil and trees than it does now, and there were fewer people to share this great wealth of resources. But the people were poor. They could not afford to live what we think of as decent human lives.

You might say, "the country was poor because it did not have all the roads and dams and factories and power lines that now make our country rich". But why hadn't the Americans of that

time built that equipment if they needed it to be wealthy? There are two reasons, and these are the driving forces behind the spread of wealth. One is that they did not know how. The other is that accumulating capital takes time. Each year you have to produce more than you consume, year after year.

Since, as I was told by a taxi-driver in Mexico City, poverty is the result of people not knowing how to do anything, the way to get rich is to learn. Basically, a nation gets wealthy by learning how to be more productive and then by accumulating capital.

"Productivity" is the key concept; it is the amount of value that an hour's work produces. We are wealthy because an hour of work today produces more than 10 times as much as an hour of work in Lincoln's time. Normally, a country can only be wealthy if its people have high productivity.

Obviously the reason we are more productive than Lincoln's friends is not that we are born stronger or smarter than they were. We are more productive because our society has learned things that theirs didn't know. Some of what we have learned is built into equipment like power plants and computers, but most of what we know that makes us so productive is expressed in the overall system that keeps producing new techniques and solving problems.

What is the difference between the US and India that causes one to be so much richer than the other? Let's do a thought experiment. Suppose that there were a miracle and when everybody woke up on the morning of January 1, 1986, all Americans were in India and all Indians in the US, and there were notices on the

bulletin boards that the transfer was permanent and everybody had better get used to it. They would have all of our machines and roads and we would have theirs. (And we had also exchanged population size.) What would happen?

Such a thought experiment should not be taken literally. (Nor should anyone think that it reflects smug national or racial superiority.) The point is simply that the Indians would find that they did not know -- as a society and, in most cases, as individuals -- how to do what is necessary to make our system work. As a result the income of this country would drop sharply.

Even though we may feel that our system doesn't work very well, it is producing at a very high level. It would be many years before the Indians would be able to make it produce as much as it it does today. The proof that much of the learning is in **our society**, rather than in individuals, is that if an individual Indian comes to the United States she can quickly learn how to do well, and how to have high productivity in our system. But when she goes back to India she will not have such high productivity. The skills learned in the U.S. may not be appropriate at home, and she can't be so effective without the rest of our system.

It is hard to think of our country as fabulously efficient and productive. Many of us are working in jobs that don't seem to produce anything at all. But we are doing something right. People buy what we produce, much of it in world markets where nobody does us any favors.

At the bottom is continuously improving technology and methods of production. Generally this requires dividing work in

new ways or into smaller pieces, and using special tools or specialized labor. (These statements use the language of physical production because that is easier to visualize, but essentially similar factors work in the service sector and in the production of intangible products.) This, in turn, creates a need for better ways to coordinate the specialized work.

The key to understanding what's going on is to realize that the complexity we need to be efficient requires a tremendous ammount of coordination and delicate decision-making. By analogy this could be called "thinking". We have to buy the efficiencies of specialization by spending a lot on some kind of "thinking" which is necessary to make these efficiencies possible.

In effect, **the system that we are all part of is the substitute for the "thinking" we need.**. "The system" is what does the job of coordinating all of our specialized efforts. It does it automatically, in the sense that we didn't design it and don't pay attention to it (but like our "automatic" system of digestion it sometimes produces a lot of rumbling, gas, and pain). And the increases in efficiency from specialization are so great that we can afford a very expensive system to provide the necessary coordination.

The system has the side effect that lots of people are doing things that don't seem to be very useful. A better system would have just as good decision-making and less decadent silliness and time wasting. But nobody has ever seen a system that was better. Nature pays to be able to avoid thinking by wasteful production; we pay for our thinking by having a social system that involves a great deal of waste.

The point of the thought experiment about our changing places with the Indians is that the primary reason the US is richer than India is simply that we have already learned to do a lot of things that India has not yet learned how to do. Our society is well adapted to high productivity. The main thing we have learned that adapts us to high productivity is a social system that lets us work together in constantly changing ways.

Of course when India learns how to be more productive she won't learn to do things exactly as we or others do them. They will learn their own way which will be about as difficult for them to learn as our way was for us to learn.

The word "learn" is misleading because it is a single word standing for many processes. Also it suggests that there are clear right answers, which is not always true. Here we are using "learning" as a metaphor to sum up many changes in the thinking and feeling and behavior of individuals and communities.

But make no mistake about it, the process now shaping our world -- economic development -- is best understood as a learning experience -- using that phrase in the broad metaphorical way I have described. If you want to understand the spread of wealth around the world, or to predict whether economic development will happen in a country, or how fast, or to understand the obstacles, or what to do to make it go faster, you need to think about how to predict or influence a <u>learning process.</u>

**Compound Interest and the Accumulation of Capital**

Two links are necessary to connect learning to wealth: the accumulation of capital, and compound interest. While wealth

is not limited by any shortage, the **speed** with which a nation can become wealthy is limited. Questions about the future of wealth are not "how much is possible?" but "how fast?"; "what rate of income growth is possible, for each nation at any time?"

The accumulation of capital includes both things and ideas. "Capital" means both money and non-monetary resources that are useful for producing. Experience, learning, and machinery are all capital. Mostly they embody work done in the past and adapted to be able to do work in the future. Capital is created when a country doesn't consume all it produces. Also when the society learns from the environment without work.

The awesome power of compound interest is not generally appreciated. Throughout almost all of human history there was no broad sustained growth. So a sustained (that is, average) rate of growth of 2% over a long period of time is rapid growth -- and a tremendous force for change. Two per cent per year means doubling every 35 years and multiplying nearly 8 times in only a century. Therefore, although growing at 2% per year sounds almost like standing still, a 2% growth rate has revolutionary effects on people's lives.

**B. Scarcity Doesn't Jeopardize the Passage to Human World**

To see why we shouldn't worry about a catastrophical running out of raw materials, we should start by looking at the raw materials we use now. Figure 5 (at the top of the next page) gives per capita raw material use in the U.S. in 1980. Briefly, it shows that out of total expenditures per capita of about $12,000, $955 was spent to buy fuels, $500 for food, and $170 for

Figure 5

**Use of Raw Materials in the United States (1980)**

| Item | Amount Used (per capita) | Cost per lb. | Total Cost (per person) |
|---|---|---|---|
| Food | 2,000 pounds | $ .25 | $500. |
| Fuels | 16,000 pounds | .06 | 950. |
| Drinking Water | 2,000 pounds | .0001 | .20 |
| Metals | 1,000 pounds | .06 | 60. |
| Wood | 2,000 pounds | .02 | 40. |
| Misc. Minerals | 2,000 pounds | .02 | 40. |
| Stone, sand & gravel | 20,000 pounds | .001 | 30. |
| | 45,000 pounds | $ .04 | $1,620. |

all other raw materials. The possibility of dangerous raw material scarcity should be analyzed in these three categories: food, energy, and everything else.

1. **Food.** The world's food supply now is about 2,000 million tons of grain equivalent. If we are to feed a rich world of 10,000 million people with American eating habits, we will need to grow 5 times as much grain equivalent, a century or two from now. (Most of the food we take from the ground is grain -- and for Americans most of the grain goes to feed animals. "Grain equivalent" counts actual grain plus the amount of grain that would provide as many calories as come from other crops.)

The problems that farmers and governments are having now with falling grain prices and growing surpluses demonstrate that famine and hunger today don't come from a lack of food but from a lack of money, or from political inhibitions on distribution.

The current food supply is grown on 2800 million acres of land with an average yield of .7 metric tons/acre. With conventional agriculture more food must come from either more acres or higher yield per acre.

**Number of acres harvested for food.** The most careful study of potential additions to the supply of arable land was made by a group of Dutch soil and agriculture experts led by Dr. P.Buringh.[1] They evaluated some ten thousand soil units in the 222 regions in which the latest soil maps divide the world. Their conclusion was that after taking into account all the basic constraints there are an additional 5,000 million acres that could be used to grow food crops. These additional acres would not be substantially less suitable than the land now used, and could be made arable at an average cost of some $1200/acre (1981 $), less than the price of much farmland in the U.S. today. There is no substantial technical challenge to the general conclusions of the Buringh group.

The Buringh study also indicated that there are 4,000 million acres that could produce at least one additional crop per year by sequential cropping (double cropping). In effect, sequential cropping could add as much grain as an additional 4,000 million single-cropped acres. (This paper considers sequential cropping with potential sources of increased acreage, rather than the more common practise of defining it as a potential source of increased yield.)

To summarize, we can say that the number of acres of food crop harvests can be multiplied by 3.

**Yield/acre.** We will limit itself to what can be done with current agricultural science, that is, with currently known techniques plus the continued application of current agricultural research techniques. (This excludes scientific breakthroughs, or exotic developments like gene-splicing, etc.)

Since benefits from recent and future scientific advance have not been counted in these estimates, if there are any such benefits they would be available to make up for unforeseen problems. This is a powerful reserve (a very conservative form of calculation).

Effective yield increases can come from the following:

a) increased inputs -- e.g., fertilizer, herbicide, irrigation, etc.

b) improved inputs and techniques (compared to present average practise)

c) higher yielding varieties of seeds

d) reduction of post-harvest losses (e.g., from rats, spoilage, etc.)

e) reduction of the grain requirements of animals used for food (currently 4 - 8 calories of grain are used for each calorie of meat consumed)

Taking all these sources together, a factor of 5 increase in average effective yield is possible over the next few centuries.[2]

World-wide average yields grew nearly 2%/yr during the 70's.[3] (The reported growth of yields does not take into account changes in post-harvest losses, nor the efficiency of conversion to meat.) If average yields grow at 1.5%/year it

would take 110 years to achieve a factor of 5 increase in yield, which is unlikely because some of the increased demand for food is likely to be met by increasing the number of harvested acreas, or in other ways.

"Artificial" farming, or non-traditional foods (e.g., algae -- perhaps for animals only) would be an additional source of supply if they can compete.

Although it is not demonstrated (and not necessary for the issue considered here), if one has to bet whether grain prices in constant dollars in the year 2,000 or 2,100 are higher or lower than today, I believe that one would do as well to bet "lower" as to bet "higher". Certainly there is no basis for thinking that they may be many times higher.

In brief, since we can point to the sources of a 15 fold increase in the renewable output of conventional agriculture, there is little reason to doubt that food production can keep up with demand, on a renewable basis, at least for a world population several times as large as that experts expect after the current surge of population growth ends in the next century -- about 10 billion.[4] (World population growth rates have increased over several centuries from near zero to a peak near 2% in the early sixties. They are now declining and are expected to be near zero again by about the middle of the next century. It is generally expected that the growth rate will have been over 1% for about 100 years.)[5]

**2. Energy.** Energy is overwhelmingly the main supply issue. The cost and sources of energy for the long run are very

uncertain. Here we address only the limited question: "Can we be reasonably confident that our huge long run needs for energy can be supplied at an acceptable cost?" (I assume that fossil fuels will not be sufficient and that nuclear energy might be excluded for political or other reasons.)

Currently the world spends 10-15% of GWP on raw energy. In the wealthy worlds of the long term future (demand would be much lower if the world were not wealthy) we could afford to spend at least 30% of GWP for raw energy -- probably 50%. If energy prices rise, we will use less energy per dollar of GWP. Therefore we can probably afford unit energy costs 4-6 times as high as today (assuming the rise is spread over a century or more). (Figure 6 on the next page shows today's world energy budget and some alternative possibilities for the year 2200.)

Approximately one tenth of 1% of the sunlight striking the Earth is sufficient to meet all of our energy needs. (Which is not to say that we are limited to the solar energy normally striking Earth.) Solar energy can be converted to any form of energy we need. The problem about solar energy is cost. The pattern of energy use in an all-solar energy economy would be so different that it is not very meaningful to compare unit costs with those today. But it is the best we can do.

One answer to our question is that we don't have to worry about being able to meet our energy needs affordably if the average unit cost of solar energy 200 years from now is no more that 4-6 times current average energy costs (about $4/MMBTU). Nobody has squarely attempted such a spacious cost-estimate. But there are a number of programs today to try to make several forms

Figure 6

WORLD ENERGY BUDGETS

| | GWP | Energy Effic. | Energy Amount | Price of Energy | Total Cost of Energy | Energy's Share of total GWP |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | col. 1 / col. 2 | | col 3 X col 4 | col. 5 / col.1 |
| | (tril.* dol.) | (GWP per Q) | Q** | (tril $ per Q) | (trillion dollars) | % |
| | | | ACTUAL BUDGET | | | |
| 1980 | $10 | 30 | .3Q | $4 | $1.2 | 12% |
| | | | ALTERNATIVE HYPOTHETICAL BUDGETS FOR YEAR 2200 | | | |
| "W" | $500 | 120 | 4 Q | $16 | $64 | 13% |
| "X" | $500 | 60 | 8 Q | $16 | $128 | 26% |
| "Y" (BASE CASE) | $500 | 60 | 8 Q | $8 | $64 | 13% |
| "Z" | $500 | 30 | 16 Q | $8 | $128 | 26% |

* A "trillion" is one million time one million (it is also one thousand times one billion).

** A "Q" is a very large amount of energy. It is equivalent to the energy in 180 billion barrels of oil, or 10 to the 18th power BTU; that is, the output of about 30,000 big electric power plants used full time all year long

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of solar energy competitive with current sources of energy in the next few decades. One must be sceptical about whether these programs will succeed, but it is reasonably conservative to believe that in 200 years large scale solar energy costs will not be more than 4-6 times as high as average energy costs today

(that is, not in excess of $20/MMBTU in constant dollars).

By saying that solar energy can provide the energy we need, I am not saying that we will or should use much solar energy. All I am saying is that solar energy can do the job if there is no better solution. Therefore there is not much basis for thinking that we eventually have to be in trouble because of inadequate energy supply.

3. **Everything else.** The $170/year per capita spent on other raw materials includes $100 for all minerals [6] (plus $40 for wood and $30 for stone, sand, and gravel). The only individual minerals on which more than $6/year is spent are iron and copper. (See Figure 7 at top of next page.)

All metals together, cost about $60, including iron and copper, which comprise about half of the total cost and 90% of the quantity of metal. Most of the other half of the cost of metals is for the 14 metals (including precious metals) each of which takes between almost 1% and 10% of the total. This leaves only about $1 per person for all other metals.

Other non-fuel minerals require $40, most of the cost of which is divided more or less equally among the following six minerals: lime, phosphate, potash, cement, gypsum, and sulfur.

For at least 100 years the cost of minerals as a group, and most individual minerals has been declining.[7]

Iron, aluminum, and other minerals capable of doing the jobs done by almost all of the minerals we use, are so widely present that it not conceivable that we would run out of them. (Iron is 5%, and aluminum 8% of the Earth's crust.) Competing products put a ceiling on the cost of copper -- probably below $5/lb.

Figure 7

**Approximate Per Capita Use of Minerals in the U.S.**
(typical year in early 80's*)

| | Quantity | Price | Cost |
|---|---|---|---|
| Iron | 600 lbs | $.02/lb | $12 |
| Copper | 20 " | .75 " | 15 |
| Other high volume metals bauxite, lead, titanium, zinc, and manganese | 80 " | .15 " | 12 |
| Expensive metals nickel, tin, cobalt, moly tungsten, and magnesium | 3 " | 3.00 " | 10 |
| Precious metals gold, silver, plat. gp. | .6 oz. | 20.00/oz | 12 |
| Misc. non-metals (primarily:lime, cement, sulfur, potash, gypsum, and phosphate) | 2,000 lbs | .02 " | 40 |
| Total (wtd. avg. price) | 3,000 lbs. | $.03/lb | $100 |

(columns do not add because of rounding)

Excludes stone, sand, and gravel (20,000 lbs, $30)

* Many of these prices and quantitities fluctuate substantially from year to year. Since the only purpose of the table is to give a general feel as to the relative importance of different items, and a sense of scale, this table smoothes the fluctuations and calls itself a "typical year".

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Thus the key point is that the U.S. is now spending at most $10-20/year per capita for all the minerals that we might conceivably "run out of" and for which there are no good substitutes. It is very hard to imagine circumstances in which costs for a major mineral -- or for doing without it -- would rise by a factor of 10. It has never happened. But we would not be seriously hurt even if the cost of all such minerals, or the cost of doing without all of them, rose by as much as 100 times.

In summary, because we now get the minerals we need with

such a small share of our efforts (e.g., $100/cap. for Americans), and since many of them are common materials, the outer limit of the effect of scarcity of minerals, taking the worst case possible, is equivalent to an annual tax of less than 5% of GWP (and most of the probability is an order of magnitude less).

4. Conclusion

The conclusion is that raw material scarcity is not a serious danger to society and therefore need not concern the citizen. Raw material supply is a matter for businessmen and experts to work out, and for them it presents a number of fascinating questions and great challenges -- which are not covered here, and which must be analyzed quite differently.

## C.Pollution Doesn't Jeopardize the Passage to a Human World

Thousands of scientists are studying questions related to pollution problems. And the problem is getting bigger and more complicated every year as the number of people and the amount of production increases, and the number of new chemicals multiplies. No one can hope to understand all of these complexities. But let's see whether we can get a reasonable handle on the human implications of pollution without going very far into these technical issues.

Before we get started on a realistic discussion of the pollution problem we can do an exercise to gain perspective:

> How clean is your house? If you spent more time and money on keeping your house clean, wouldn't it be cleaner?
>
> How dangerous is your house? How many smoke detectors and burglar alarms do you have? Have you checked to see whether there are internal air contaminants? Is all your

electric wiring properly grounded?

Even though the world's problems are not so simple as keeping a house clean and safe, we can learn something about the general nature of the world's problems by thinking about people's houses. Basically people's homes are as clean and safe as they choose to make them. They could be made safer by spending either time or money (or effort to learn how). So we choose our level of safety by deciding when to stop spending time and money on making our houses safer.

Although the world environment is infinitely more complicated than our homes, our environment, like our home, will be as clean and safe as we choose to make it. Almost certainly the thing that will keep it from being cleaner and safer than it is will not be some inherent limit of nature, but human decisions not to exert additional effort to make it cleaner and safer.

But there are three "catches" that ought to concern us about the analogy between the world's pollution problem and our home environment.

Catch number one. Sometimes we don't avoid a danger because we don't know about it. Who knew that installing asbestos insulation might be dangerous? I call this problem "sneaky pollution", and it is discussed below. There is no guarantee against sneaky pollution, and no clearly safer strategy for minimizing the risk.

Catch number two. We know that the cost of keeping our house clean is reasonable, but how can we know that the cost of keeping the environment clean is reasonable, especially in the distant future? Good question. See below for a pretty good

answer.

Catch number three. I can decide to spend the necessary effort and money to keep my own house clean (at least if I live alone), but our individual decisions aren't enough to keep the environment clean. Protecting the environment requires cooperation among many people, sometimes people in a number of different countries. This is the "common property" problem, and it makes things much harder. But it is not by any means the only or worst "common property" problem. We are dependent on decisions of others for many other things that are as important to us as the quality of the environment.

**What Does Experience Suggest about Pollution in the Future?**

There are no obviously decisive statistics. Some places are getting better at the same time other places are getting worse. And since pollution includes many different things, any one place may be getting better in some ways and worse in others. Since so many facts can be shown pointing in opposite directions, the only way to think about what the trends are is to try to understand the overall patterns.

One common pattern is old forms of pollution disappearing and new forms arising. Horse manure in city streets and soot from residential use of soft coal were once big problems, but are no longer. Dysentery germs in urban water supply were once an even bigger problem, and now have essentially disappeared from advanced countries. But now sulfur dioxide and carbon monoxide from cars and modern industrial plants are problems.

Another common pattern is results from economic development.

When a country moves from primitive, very poor, conditions to the very first stage of economic development, pollution usually is reduced, as plumbing and sewer systems and other basic measures for cleanliness become understood and affordable. The next stage of development often brings industrialization and increases in pollution. Later the industrialization often produces enough wealth so that the country wants to, and can afford to, take control measures that reduce pollution.

President Carter unintentionally illustrated this pattern with a story he once told about Japan. He said that he had heard that Tokyo's massive program against air pollution was initiated after the Emperor had noted sadly that there were no longer butterflies in the Imperial Gardens. And now, as a result of those programs, the butterflies are back in the Emperor's garden. President Carter's story illustrates a basic pattern that is likely to be repeated in many countries: first butterflies and poverty, then development and no butterflies, then wealth and butterflies.

**How Should We Understand the Basic Idea of "Pollution"?**

The idea of pollution includes two different kinds of things: dirtiness and danger. We spend money to reduce pollution because we want to be cleaner and safer. And we can include wilderness preservation, the protection of scenery, and other concerns for the amenity values of the environment, as forms of cleanliness.

While safety is often talked about as an absolute requirement, modern science can detect such infinitesimally small "dangers", that the decision about how much "health-threatening"

pollution to allow also becomes a matter of preference or efficiency, not an absolute.

Taking all these considerations into account it turns out that there are two quite different kinds of pollution problems that have to be dealt with. I call these "mass pollution" and "sneaky pollution". With "mass pollution" you know what is the pollutant and that you don't like it; the problem is spending the resources to get rid of it. With "sneaky pollution" you don't realize how bad it is until it is in the environment, the problem is knowing in time.

As a practical matter, of course, it is not so simple. Usually some people know the facts while others are ignorant or disagree. And sometimes only part of the harm from a pollutant is understood. Sometimes there is genuine technical uncertainty; sometimes there is controversy because people have different interests and values. And people can even disagree about whether something is harmful, harmless, or useful - like fluoride in the drinking water. But even though in some cases a mass pollutant will also be somewhat sneaky, it is useful to think separately about: (i) the problem of how to get something that is recognized to be "garbage" out of our environment; and (ii) the problem of how to recognize what really is "garbage" (because if we let too much of it get into our environment it will cause harm.) Where "harm" means either dirtiness, ugliness, unhealthiness, or danger).

**Mass Pollution**

Most pollution is "mass pollution"; that is, we know

what is causing our problem -- either dirtiness or danger or both. But it is expensive to get rid of or prevent the pollution.

The basic fact about mass pollution is that in the long run we will have only as much as we "decide" to have. It is our choice. Cleanliness is like other products: you can buy as much as you want and have money to pay for. Of course the avoidance of pollution, which is community cleanliness, is a "common property", like defense or a stable currency. Individuals can't buy such common properties, only groups can.

There are several problems that come from the fact that community cleanliness is a "common property". The community may buy more or less than any individual would prefer. You can't please everyone. Also the purchase of cleanliness is more complicated than buying potatoes. It is often hard to know what is the efficient way to buy it, and the best way may be 100 times cheaper than the obvious way.

Each country or region (and for a few pollutants the world) has to decide how much cleanliness and safety it wants, and what actions are the best way to buy it. In practise, obviously, it is much more complicated to make this set of decisions than I make it sound, and often they are not made nearly as well as they might be.

Decisions about how to produce a common property like environmental cleanliness are made by a political process. And political processes are not usually good at finding the efficient answer to technical problems because they are designed to preserve domestic peace and achieve democratic or other political

values -- not to do good research. Therefore we may have a lot more pollution than many people want, and/or waste a lot of money on foolish anti-pollution measures. But there is no reason to believe that political incompetence will produce disaster in pollution control before it produces disaster in war avoidance or tyranny avoidance or depression avoidance.

**The Cost of Mass Pollution**

In 1975 Resources for the Future (RFF) arranged for Ronald Ridker and William Watson to do a four year study of the resource and environmental consequences of different growth paths that the US might follow during the next 50 years. The results of this study were published in 1980 with the title To Choose a Future.

The Ridker & Watson team (R & W) estimated the amounts of materials and energy that would be needed for many possible combinations of population and economic growth in the US during the fifty years from 1975 to 2025. They then estimated the amount of the major forms of mass pollution that might be produced by all of the necessary mining, manufacturing, power generation, etc. They also considered the effect of many different pollution control laws.

Of course the mass pollution problem imposes two kinds of costs on us. First there are the "pollution control costs" spent to prevent the pollutants we produce from getting into, or staying in, the environment. Pollution control is like a production task. It involves designing and procuring pollution absorbers, pollution sinks, pollution-avoiding production

technology, etc.

The second kind of cost of the pollution problem is "pollution effects costs", including things like cleaning costs, damage to property as a result of pollution, health care costs, and the value of reductions in health caused by pollution.

Most of both kinds of pollution costs are very difficult to estimate, even when you know all the facts. But even though no confidence can be placed on any one estimate (for example the cost of removing sulfur dioxide produced by 300 big coal-burning electric generators in 2025), the sum total of the many thousand estimates is reasonably useful, even if each separate estimate is almost worthless.

Many possible mistakes and unpredictable factors produce underestimates, while others produce overestimates. If the estimators are not trying to push the results one way, the errors in each direction tend to balance each other.

What Ridker and Watson did to pull everything together was to make about seven different scenarios for the next 50 years. For each possible combination of production scenario and pollution control law Ridker and Watson estimated (i) the total cost of the pollution control programs, and (ii) the expenses caused by the pollution that was allowed to remain in the environment. The sum of these is the total cost of pollution, as best as can be calculated.

For the United States in 1975, for example, where R & W had real costs to observe, pollution control costs were about $18 billion and pollution damage costs were about $48 billion. In other words, R & W estimated that in 1975 pollution cost the U.S.

a total of $66 billion, which was like a tax of 7% on everything we bought.

R & W calculated that the "pollution tax" will be between 4.4% and 6.4% in the year 2025. Their detailed analyses show total pollution costs going **down** regardless of which growth path our economy follows, and whether our pollution control laws are at the relaxed or strict end of the range of possibilities that seemed reasonable to them.

The R & W conclusions were: "...environmental damages from the mass pollutants covered in this chapter are likely to remain the same or fall over time despite the growth in the economy and greater number of people at risk. .... In all cases, after 1985 they fall over time on a per capita basis and as a percentage of consumption."

In other words, no matter how much the U.S. grows we can have less pollution damage than now by paying the costs required to keep clean -- and the costs won't be very high.

Ridker and Watson's work stands today as by far the single most thorough and substantial effort to evaluate long term pollution costs. It is the best evidence we have, and it says quite clearly that for the next 50 years in the U.S., regardless of how fast we grow, mass pollution will cost us less than it does today.

If R & W are correct that pollution costs are going down over the next 50 years in the richest large area of Earth, it is a powerful piece of evidence that further economic growth in the world in the long term does not have to increase the pollution

tax that people need to pay to maintain the quality of the environment.

The fact that it is difficult to make good decisions about buying cleanliness doesn't change the basic situation; we the people, not nature, determine how much mass pollution there is. Nature will allow us to have all the raw materials we want at reasonable costs with about as little pollution as we choose and without spending a noticeable share of the economy for pollution control. While many people seem to contradict this basic point, in fact they have not examined this question and do not challenge this conclusion.

There is no evidence or sensible theory that we will have to pay very much to have an environment that is in better condition than the one we have today. This conclusion holds for tens of billions of people and very high living standards, with very large consumption of energy and everything else that goes with it.

**"Sneaky Pollution"**

While with mass pollution the problem is deciding how much cleanliness to buy, and buying it efficiently; with sneaky pollution the problem is knowing what's happening.

Here is where all those who insist that there must be something to worry about can have their day. "Sneaky pollution" is defined as a category to give room for most of the "what if...?" questions that can't be answered.

We can't know for sure all the effects of what we do. I define "sneaky pollutants" as any phenomena that turn out to cause more trouble than was originally thought. So the idea of

"sneaky pollution" brings together all the harmful effects that we are unable to predict. The concept is broader than just chemicals. Many germs or bacteria are good examples of sneaky pollutants. Until we find out about them they cause many deaths.

One dramatic example of a sneaky pollutant was methyl mercury. At one time people believed that it wasn't absorbed by the human body and therefore that industrial wastes containing methyl mercury were not dangerous. The error was discovered only after hundreds of Japanese and others received deadly or disastrously harmful doses. Once the cause of "Minamata disease" was discovered the discharge of methyl mercury was virtually stopped almost overnight.

Various forms of natural pollution that produce malaria or dysentery or other diseases have been quickly limited once the danger from them was recognized, that is, as soon as they were recognized as pollution. Such natural sneaky pollutants have caused millions and millions of deaths.

We are especially interested in man-made sneaky pollutants. We want to know whether we will make things or do things that are surprisingly dangerous, perhaps cumulatively over a long time, or to later generations. Will we do things that, if we knew what the results would turn out to be, we wouldn't do them? To be blunt, will we make mistakes that kill many people? The answer is "yes". Our mistakes have caused millions of deaths in the past, and probably will in the future.

By definition we cannot stop sneaky pollution -- because we don't know what it is. As soon as we recognize it, it becomes

mass pollution. So how can we estimate how big the problem of sneaky pollution will be and what can be done about it, since by definition we don't know what the problem is? More important for our concerns, does the problem of sneaky pollution get worse if the world population gets very large and very rich?

The short answer is that we can't know how bad sneaky pollution might be. It is entirely possible that some form of sneaky pollutant will kill everybody and end the human species. And it is quite likely that sneaky pollutants will in the future, as they have in the past, kill millions of people.

Therefore I want to be very clear that I do not mean to say that we don't have to worry about sneaky pollutants. There is no assurance that they will not cause immense harm. But, on the other hand, there is no reason for thinking that sneaky pollution is anything like the most dangerous problem we face. (The phrase "no reason for thinking that" means exactly what it says; it does not mean "it is definitely wrong to think that".) And there is no way of knowing whether more population and economic growth will increase or decrease the total harm from sneaky pollution.

Three things determine how much harm we will suffer from sneaky pollution. First is the number and nastiness of sneaky pollutants. Second is the speed with which technical people expose the sneaky pollution, that is how quickly they learn that a mistake was made. Third is how quickly the society acts to correct the mistake once it is discovered.

It is reasonable to think that the more the world economy grows and advances technically, the more sneaky pollutants of every degree of nastiness will be produced. But that doesn't

mean that sneaky pollution will cause increasing harm. The decisive question is whether our ability to respond to the sneaky pollutants grows faster than the sneaky pollutants do.

Presumably our ability to find the sneaky pollutants will increase as the level and quantity of our science and technology rises. But after scientists found that feeding citrus fruits to sailors would prevent scurvy, it was 30 years before the British navy began providing limes to their sailors. And it was another 40 years before the "new technology" of limes was transferred to the British merchant marine, although frequently 25% of a ship's crew might die of scurvy if the ship did not provide limes or some other source of Vitamin C.

It is harder to guess whether when the world economy gets bigger and richer we will become quicker or slower to act against pollution dangers after they are uncovered by scientists. It depends on what might be called "social wisdom". And anyone who thinks he can predict whether social wisdom will increase or decrease in the future is welcome to the job. But other things being equal people are more able to recognize dangers if they can see what needs to be done to deal with them and if they can afford to do it. So increasing wealth means that a little less social wisdom is necessary to respond to newly-recognized pollution mistakes. Also, as people get wealthier they usually decide to spend increasing shares of the income on safety and aesthetics. This is another way in which wealth may speed the response to sneaky pollution.

In brief, sneaky pollution is a problem to which there are

no guaranteed answers. It will be costly and it may be disastrous. But we have no good reason for thinking that it is a problem that will get worse as we complete the passage from natural to human worlds. Clearly we are likely to produce more sneaky pollutants, but equally clearly, our ability to reduce the harm from any particular sneaky pollutant will also grow. It is the balance between these two effects that is unpredictable -- although I would bet that our ability will increase more than the challenge.

## IV Conclusion

The necessary concluding comments are contained in Figure 8 and Figure 9.

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Figure 8

INTEGRATING THE TWO PERSPECTIVES

DILEMMA

1. WE ARE RAPIDLY CHANGING FROM A NATURAL TO A HUMAN WORLD.
2. BUT ALL THESE "TERRIBLE PROBLEMS AND DANGERS" EXIST.

RESOLUTION

1. FOR EACH "TERRIBLE PROBLEM OR DANGER" ASK:

   "DOES IT REALLY THREATEN THE PASSAGE TO A HUMAN WORLD?"
   (IT ALMOST CERTAINLY WON'T.)

2. IF NOT:

   WORK ON THE PROBLEM,
   BUT PUT IT IN THE CORRECT PERSPECTIVE.

   - PHYSICALLY WE CAN EXPECT TO BE OK
   - WORK AND WISDOM CAN SPEED THE PASSAGE AND REDUCE THE COSTS
   - OVERREACTION AND RADICAL CHANGE USUALLY MAKE THINGS WORSE
   - THE U.S. IS PART OF THE SOLUTION NOT THE PROBLEM

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Figure 9

## SOME THINGS I AM NOT SAYING

1. WE'RE SAFE. THERE IS NO DANGER.
2. NOTHING NEEDS TO BE DONE.
3. WE KNOW THE FUTURE.
4. WE NOW KNOW EXACTLY HOW TO SOLVE ALL OUR PROBLEMS.
5. "PROGRESS" IS INEVITABLE. (I.E., "THE WORLD KEEPS GETTING BETTER."
6. THE WORLD WILL BE BETTER IN THE FUTURE

## WHAT I AM SAYING

1. THE THREATS TO MANKIND FROM SCARCITY, POLLUTION, OR ANY LIMITS IMPOSED BY THE PHYSICAL CONDITION OF THE EARTH, ARE SMALL.
2. OUR BASIC EXPECTATION SHOULD BE THAT ALMOST ALL COUNTRIES WILL BE WEALTHY WITHIN A CENTURY OR POSSIBLY TWO.
3. MANKIND'S REAL WORRIES ARE HUMAN - NOT PHYSICAL
   - DECADENCE (TOO MUCH WEALTH, POWER, FREEDOM, & KNOWLEDGE)
   - WAR
   - TYRANNY (Especially communism)

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