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Reconciling Economic and Ecological Theory on Population

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IIASA Working Paper

WP-89-027

March 1989

WORKING PAPER

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Foreword

At one time economics and ecology said the same thing about population: beyond a certain moderate density an increment of population will be harmful. But in recent years neoclassical economics has diverged sharply from biology. Now if the administrator asks an economist of this persuasion whether promoting birth control is important he will get the answer "Not very"; if he asks a biologist he will get "Very important". The administrator is left to resolve a question that is too difficult for the scholars in the field.

This puts an unprecedented ambiguity into the policy analysis of population. What is needed is a theoretical framework in which both disciplines are incorporated, so that there will be one recommendation only, rather than two that cancel one another out.

The two papers that follow are a first attempt at such a reconciliation. People are seen as living within an economy, and the economy is located within the ecosphere. Mediating between them is the culture, that both sets objectives for individuals and provides the technology by which they attain those objectives. On this theoretical approach the population is at the center of a succession of nested boxes representing the economy, the culture, and the environment. The papers work out some of the consequences of this approach. They recognize the flexibility of substitution under the price system, as well as the limits the environment sets on any possible economy.

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MANAGING WORLD POPULATION

THE BIOSPHERE

If the planet Earth is represented by a globe two feet in diameter, the biosphere within which human and other life goes on is a shell on the exterior of that globe. If the globe were truly a miniature of the planet most life would be contained within the paint that designates countries and geographical features on its surface. However it is defined, the mass of the biosphere is less than one percent of the mass of a planet that itself is small in relation to the solar system and insignificant as a part of the galaxy.

To think effectively about that small and fragile biosphere and the 5 billion people supported in it we must take account of

- its economies,
- its cultures and especially the technologies by which goods and services are produced,
- the non-human environment.

POPULATION, THE ECONOMY, CULTURE, ENVIRONMENT

These are best seen as boxes within boxes. Humans look after their material needs by means of an economy, and the economy is embedded in an ecology. The interaction between the economy and the ecology is mediated by the culture. We people are thus the center of a sequence of nested boxes—moving outward from us as a population we find ourselves supported successively by the economy, the culture, and the environment or ecosphere. The economy can only use such materials as are available in the ecosphere; its means of using them constitute the technology that is part of the culture.

Another part of the culture is the purposes for which people live, and which determine the goods and services that they put the economy to procuring for them; the purposes—what they regard as "good", as the unquestioned purpose of life—range all the way from owning irrigated rice land in Java, to owning a herd of cattle in the Sahel, to driving a Mercedes in Europe. The ultimate may be an activity rather than a possession—performing bravely as a member of an Iroguois war party, or praying and fasting to prepare one's soul for the next world; these different ends require different sorts of equipment. What people set the economy to procuring, and with what technology, greatly affects the ecosphere, and with the large populations now extant the effect can be massive.

Those three nested boxes are of course a scheme of analysis rather than concrete objects. Their purpose is to unify what the several disciplines have to say about population, to avoid the confusion that results when disciplines draw their conclusions independently of the findings of other disciplines that deal with the same objects. Contemplating the

economy in abstraction from the ecology easily leads to the conclusion that population can expand indefinitely; this a mistake that the classical economists carefully avoided. With the greater academic specialization of today, one discipline can say that there are too many people and another that there are too few, so population policy is left hanging. Theory and data that embrace the three boxes simultaneously ought to produce unambiguous conclusions.

For such combined analysis we need a long view; the several phenomena operate in different time scales. The economy shows significant changes month by month, while changes in the ecology proceed over decades and centuries. This factual discordance is amplified by a discordance in data. We have formidable means of keeping track of the economy, but virtually no time series on the ecology. We do not systematically follow the extinction of species, the spread of deserts, the pollution of the oceans as we follow the prices of stocks, the profits of corporations, the exchange values of currencies. We have a world census of population every ten years, but no corresponding world census of the non-human species on which the population depends.

The partial data can be misleading, as where the national income includes payment for the work done to restore the damaged environment, for example after an oil spill, but makes no subtraction for the damage itself. It thus reports us as getting richer and richer in the measure in which we do damage that needs restoring. This is more important now than when we were few and our technical means were feeble. The ecosphere affects us greatly even though it is statistically invisible. And that which is made visible by statistics is often given a biased name: our accounting systems call "production" much of what is ecological destruction—for example the removal of fossil fuels from underground deposits and their burning in internal combustion engines on land or in the air.

The life we know is as small in time as it is in space. As recently as 10,000 years ago agriculture was invented, people gathered into small neolithic settlements, and a form of writing supplemented oral communication. What we can call a human consciousness emerged. At that time, 1/5 of a second ago on the one-day scale of earth's history, there were 5 to 10 million of our ancestors, not enough to exercise much influence on the ecology in which they lived and worked. It is only in these last 10,000 years that the planet has come to be fully occupied by man, and in decades (say the last millisecond) in which industrial civilization has existed, human agency has made changes comparable in magnitude with those over millions of years of geological time. Forests that grew over millennia, soils that took millions of years to create, are used up in a single lifetime.

The population of the world at mid-century was 2 1/2 billion; some time in 1987 it passed 5 billion, who suffice to crowd into and transform every accessible part of the planet. The increase in the last 40 years was equal to the total increase over the millions of years from when pre-humans came down from the trees up to 1950. According to projections made by the United Nations, another 35 years, to 2025, will see a further increase to 8 1/2 billion. As recently as Shakespeare's time England had fewer than 5 million people; it was 200 years after Shakespeare before the United States attained 5 million. Now they have respectively 50 and 245 millions.

Looking at the prospective increase of 3 1/2 billion from 1985 to 2025 we find that only 178 million of it is in the countries that are classified as developed, while 3,434 million will be in the LDCs, again according to the UN estimates. That is to say that only 5 percent of the anticipated increase will be in the MDCs; 95 percent will be in the LDCs (Table 1).

Should we be worrying about this absolute increase of 3.592 billions, or should we take satisfaction in the observation that the increase is slowing? Between 1980 and 1985 the total population increased by 9 percent; between 2020 and 2025 the projected population goes up only 4 percent. Yet the absolute curve is sharply upward.

Table 1. Population of the world, less and more developed countries 1950–2025 (000,000).

Year	World	LDC	MDC
1950	2515	1683	832
1955	2752	1864	887
1960	3019	2075	945
1965	3336	2333	1003
1970	3698	2649	1049
1975	4080	2984	1096
1980	4450	3314	1136
1985	4854	3680	1174
	Projection		
1990	5292	4087	1205
1995	5766	4531	1235
2000	6251	4989	1262
2005	6729	5442	1287
2010	7191	5883	1307
2015	7640	6314	1325
2020	8062	6722	1340
2025	8467	7114	1352

Source: Tape provided to the author by the United Nations, giving its 1988 assessment for 182 countries and regions of the world.

The ambiguity for total population is even more striking for births, as Table 2's birth numbers and rates show. The absolute numbers of births will still be considerably greater in 2020 than they are now. It will be well into the second quarter of the 21st century before the absolute number of births will come down even to the high levels of today, while the population curve will continue to slope upwards well beyond that time.

Thus we have two views in confrontation with one another, both based on empirical data. On the one hand, the crude birth rate has been declining ever since 1950; it is now lower than a decade ago and its decline will undoubtedly continue. Those rates reflect average behavior in a way that totals do not. Yet on the other hand, absolute numbers are rising, and it is not rates that crowd and pollute, but absolute numbers of people.

One presentation of population time series can give the impression of impending explosion; another suggests impending extinction. Even in the part of our subject most solidly documented by statistics there is ambiguity.

A similar issue arises on attributes of people. It is probable that the absolute number of people in the world who are hungry is increasing, while the fraction that they are of the total population is declining. Is this progress or retrogression?

The impact of people depends not only on their numbers but on their setting in the biosphere. Here again existing statistics have major gaps; we do not know how many are cattle herders on arid lands; how many are dependent on crops produced by fossil water and the rate at which that water is being used up. We do have the territorial distribution of people, as in Table 3, that shows the ten countries with over 100 million people in 1988, again as estimated by the United Nations. But these political units are not appropriate for ecological analysis; we should have the indigenous population living in tropical forests, people living less than one meter above sea level, those in river basins subject to periodic flooding.

Table 2. Population, births and birth rates, World, 1950–2020.

Year	Population (000,000s)	Annual births (000s)	Crude birth rate (per 1000)
	Estimates based on data		
1950	2515	93,902	37.33
1955	2752	97,923	35.59
1960	3019	106,418	35.25
1965	3336	112,966	33.88
1970	3698	116,879	31.65
1975	4080	115,898	28.43
1980	4450	120,610	27.11
1985	4584	125,874	26.03
	Projections		
1990	5292		131,381
1995	5766		135,234
2000	6251		136,223
2005	6729		137,474
2010	7191		139,230
2015	7640		139,234
2020	8062		138,570
2025	8467		137,909

Source: United Nations, 1988.

Table 3. Population of the ten largest countries, 1988 and 2025 (000s).

	1988	2025	Av. % inc.
1. China	1,103,983	1,492,550	0.76
2. India	818,782	1,445,570	1.43
3. USSR	283,682	351,450	0.54
4. US	245,414	300,796	0.51
5. Indonesia	174,951	263,251	1.03
6. Brazil	144,427	245,809	1.34
7. Japan	122,424	128,596	0.12
8. Pakistan	114,939	267,089	2.13
9. Bangladesh	109,579	234,987	1.93
10. Nigeria	105,471	301,312	2.66

We get some hint of ecological change from the sequence of changes during the 37 years, with Pakistan, and Bangladesh passing Japan, and Nigeria catching up to the United States. That poorer countries overtake and pass richer countries in population will by itself adversely affect global income distribution.

CHANGE PRACTICES OR CONTROL POPULATION?

Cultures have modified themselves in response to their visible effects on the environment. What we call traditional good farming or good forestry practice is maintaining the land in such condition that it will keep producing indefinitely; in Europe and America, as well as much of Asia, the traditional perspective was long range. But tradition is not everywhere a protection: the loggers of Nepal, like the cattle-raisers of the Sahel, have improvident traditions. They do not seem about to change their practices; indeed they are too poor to risk any change at all, and the more of them there are the more quickly they destroy their resource base.

One can say of them as of many other groups: if they were fewer they would destroy less; if they had better practices they would destroy less. If the automobile-users were fewer they would consume less fuel and generate less smog; if they moved around with public transport they would similarly use less fuel and generate less smog. Everywhere we turn we meet this symmetry between numbers of people on the one side and harmful practices on the other.

This makes possible endless debate on the policy to be followed. The populationists can say that the number of people does little harm in itself, but only exacerbates the effect of bad practices. Ecologists can say that the bad practices should of course be rectified, but meanwhile the population had better control its numbers.

WHEN MORE PEOPLE WERE NEEDED

It is the RECENCY of the population growth and the assault on the environment that makes it hard to appreciate the damage being done. After all, through long ages more people were desired. They added to the strength of the family that bore them and of the kingdom in which they labored. In 17th century Europe the weaving of cloth was labor intensive, and populations were much smaller than the land could sustain, so a ruler could in effect turn people into cloth, and cloth could be sold abroad and so turned into gold. Masses of laborers could still be used in the early phases of the industrial revolution.

Since then population has everywhere increased greatly and at the same time techniques of production have changed. Beyond those changes an equalitarian ethos has spread. As Alfred Sauvy tells us in an illuminating metaphor, the farmer optimizes by having the maximum number of cows his land can adequately feed. But the optimum for the cows is not the same as the optimum for the farmer. A farmer aiming to maximize the per capita amenities of his cows (read people) would have far fewer of them. Once the cows are in a position to demand equality with the farmer the hour of Malthus has arrived.

The three conditions applying up to the 19th century—small population in relation to fertile land, technology that requires masses of laborers, and concern for the welfare of rulers rather than of peoples—apply much less today. Food supplies in many LDC areas are precarious and labor-saving technology makes it more difficult to turn unequipped workers into gold. Quite the contrary—LDCs spend gold (i.e. US dollars that they do not have) to buy equipment in order that they might employ their populations. And the equipment (designed to be used in countries where labor is scarce) requires relatively few people to run it, so even at the height of the borrowing the unemployed kept increasing.

Are the unemployed evidence of overpopulation? Or are they not rather evidence of a badly run economy, in which wages of those who do have jobs are kept artificially high? Anything, including labor, will remain unused if its price is maintained above what buyers can afford to pay for it. Where national leaders see the absolute political impossibility of freeing their labor markets, they at least want to add as few further people as possible, knowing that one birth prevented now is one less unemployed in 2010. And

since the same political forces are spreading education rapidly, that unemployed person is likely to be a high school or college graduate, and therefore especially dangerous to political stability.

ENVIRONMENTAL ISSUES IN POOR COUNTRIES

Thus various elements of the technology and the political culture threaten stability as population increases in the LDCs. Beyond them environmental issues are emerging in the LDCs—one is floods due to deforestation, whose effects are accentuated by the rise in ocean levels. Thailand has recently banned all logging, and Malaysia is considering the same, even though for these countries timber and its products are an important source of foreign exchange. Bangladesh suffers from timber cutting in Nepal and can do nothing to check it.

The rise in levels when the oceans warm up is an especially grim prospect for the countries that have large populations in flat river deltas like those of the Ganges and the Mekong. Much of the population of Java lives close to sea level. On some Pacific islands the entire territory is at risk. One can see environmental refugees moving inland from the coasts throughout Asia, and Australia is already discussing what to do if refugees come to it from submerging islands.

Emil Salim, Indonesia's Minister of Population and Environment, has spoken of the need for defenses against the sea. These are expensive—they may fit into the budget of the Netherlands, but hardly into that of Bangladesh. The carbon dioxide that is the cause of the trouble is mostly produced by the industrial countries; its harmful effects will be felt by some of the poorest of the LDCs. (And this at the same time as the banks of the industrial countries are trying to collect debts, while the governments of the industrial countries raise obstacles to the import of their goods—the only means by which the debts can be repaid.) All of these elements drastically affect the capacity of the LDCs to support present and prospective populations.

TIME FRAMES FOR THE ECONOMY AND THE ENVIRONMENT

What do extinction of species, forest dieback, carbon dioxide in the atmosphere, and the exploitation of the Amazon have in common? That none of them will affect us much in the next few years, but all of them will have serious consequences during the 21st century. These long-term, slow acting phenomena could nullify much of the real economic progress that we enjoy, and we need to see as things are now set up what institutions and what individuals are monitoring and controlling them.

The future is very much thought about by economists, who summarize the way it acts on the present through the rate of interest or discount. If the interest rate is 9 percent then a good that we will receive a year from now is worth only 1/1.09 as much as the same good receivable today. When the economic actors make calculations in this way the free market is supposed fairly to evaluate future goods and bads.

But is the rate of interest established by transactions between lenders and borrowers the right one for evaluating future events in the biosphere? At the current interest rate paid on treasury bills, a loss of the entire wheat crop through drought in the year 2100 is to be multiplied by 1/(1.09) to the 110th power (equal to 0.000076) to establish the equivalent loss today. The world crop of all cereals in the year 2100, say 3 billion tons, is thus only worth about 200,000 tons now. Businessmen responsible to shareholders cannot afford to take any other attitude to the future than to discount according to the rate at which they borrow and lend money. Yet the year 2100 would in due course come around, and there would be no wheat, rice, or corn, no meat derived from these—in short universal starvation.

If the custody of the planet cannot be safely trusted to the market, then it must be placed in the hands of government. But experience shows that governments have an even shorter perspective than business. In the spirit of democracy they discount heavily any events occurring after the next election.

Many who distrust both business and government as custodians of the future console themselves with the thought that things are changing fast, and some way of circumventing environmental danger and resource exhaustion will be discovered in time. Bioengineering will make a second Green Revolution (perhaps based on plants that thrive on salt water) that will remedy the hunger left over from the first. When we run out of oil we will have safe fusion to fall back on, so electricity will be cheaper than ever. Long before the commercially exploitable sources of copper are used up, electricity will be transported by ceramic superconductors. In a free economy where everyone pays for all benefits received (i.e. there are no externalities) shortage of any kind generates the technical change that circumvents the shortage.

With powerful technology prompted by the market it is government that seems to prevent the economy from substituting and adapting and so creates all our troubles. Yet this common negative way of describing government does an injustice to its role in establishing a free market. The market is far from natural, but requires a rare kind of government: one assigned unlimited power to maintain law and order and private property (including elimination of externalities), that then refrains from abusing this power to its own advantage. And the more it abuses, the more protest is engendered, the more maintaining itself in powers takes precedence over all other concerns, and the less it will yield to the power of the market.

Where such self-denial cannot be counted on the substitution and flexibility of which the economy is capable will be only partially available, technical skills only partially engaged. There will be the shortages and dangers that we know, along with their effect on the capacity to support population. In particular national authorities find it nearly impossible to act together to internalize damage to the planet.

EQUILIBRIA

Other articles of this issue of *Scientific American* deal with the equilibria of natural processes. Here it need only be said that the forces under the control of man, large though they seem, are wholly inadequate to rectify major disequilibria in nature. It is as though we had the Washington monument standing on its point; if there were no wind and a refined monitoring of its verticality it could be maintained in that position with almost no force—the muscles of one man could keep it in balance. But once it started to tilt and fall no existing equipment could hold it. The analogy applies to the temperature balance of the planet, as to the balance of species in a tropical forest threatened with pioneer-type cutting. Not only is our industrial society brief in time, and occupying the paper-thin surface of the planet, but the forces it commands at any one moment are small in relation to the cumulative changes that it is causing in various global equilibria.

WHERE TECHNICAL ADVANCE LEAVES OFF

Technical advance is not likely to oppose those geophysical forces that we have set in motion. No technology is going to counter the warming of the atmosphere or fill the hole in the ozone layer. If the market cannot cope with them, and governments give them low priority, then to whom can we turn? Scientists do not command the facilities, political or financial, to lower automobile speed limits or to force the abandonment of dangerous aerosols. West Germany has the largest scientific establishment and the largest green party in Europe; it is also the country with no speed limits on its highways. Its auto-makers have more influence than its scientists. So forest dieback accelerates.

For individual countries, let alone for the planet as a whole, the mandate to protect the ecosphere is unassigned. The least one can say is that every aspect of the problem is eased by having fewer rather than more people.

All this disturbs the comfortable vision of a world wide high consumption society, in which well paying jobs are available for those who can work, and those who can not are covered by social security paid for out of high and increasing production. The consumer society where social ascent is proven by two automobiles and two homes for every family remains the ideal. With no more than one quarter of the planetary population sharing that middle class life style, and it not fully, we already have problems: acid rain is destroying forests in Germany, Canada, and elsewhere; the fisheries catch has ceased to increase, coal is polluting and the hoped-for transition to nuclear has been postponed by high cost and political resistance, land everywhere is overcropped. Americans may have somewhat lowered their consumption of meat, but others are eating more, and so passing ever more corn through animals on its way to people. The well-off in the rich countries may have started to see through the social mobility game that is so expensive in space and resources, but those who have not yet climbed the ladder are pressing to get a foot on it.

MODERN RESTLESSNESS

Much of the damage to the ecosphere is related to movement and travel. A middle class American eats somewhat more than an Asian peasant, has somewhat more clothes, has more varied entertainment, but none of these require extravagant amounts of resources. In an ecological perspective it is the mode and amount of movement that principally distinguishes the American town dweller from the Asian peasant.

A person can walk a mile on 100 kcalories, say burning one slice of bread; 5 billion people walking 10 miles per day take a few million tons of grain more than they would need if wholly sedentary. For an automobile to go one mile requires 1/10 of a liter of gasoline, say 1000 kcalories. There are now 500,000,000 registered automotive vehicles on the planet (473.4 million in 1984—*Stat. Abstr. 1987*, p. 826), and on the average they use nearly 2 gallons of fuel per day, or about 1/20 of a barrel of oil. Filling the tanks of the world automobile fleets takes about one third of the 60 million or so barrels of oil raised above ground each day.

Most of this feverish movement is of the 1.2 billion people in the MDCs; the 3.8 billion in the LDCs move much less. We can think of the former as circulating within a radius of 50 miles, the latter of 5 miles. But things are changing. Up to recently the major part of annual automotive production for replacements and new cars has served the MDC populations. With the present rate of economic progress we can expect that the annual net global increase in registrations of 4.5 percent will continue, but with less and less of it in the MDCs, now nearing saturation of their markets; most further expansion will be in the LDCs.

Notice that the trend in automobiles and planes is upward, and at a sharper angle than that of population. If it goes up by the past rate of 4.5 percent per year and population by less than 2 percent, then year by year the output of the byproducts of combustion engines increases more by economic growth than it does by increased population. By 2025 the population will have nearly doubled from the 4 1/2 billion of 1980, the automobiles will be fourfold, having doubled twice. With fixed efficiency each person will be contributing about double the carbon dioxide, nitrous oxide, and other chemicals as in 1980.

The technology is available to serve the purposes of much of this travel by ecologically softer means. Video telephones could allow friends and relatives to keep in touch; video conferences could replace much of business travel; TV and video tapes can show the scenery on other parts of the country or the globe that people now travel to. Yet viewing foreign landscapes on TV has stimulated rather than diminished travel.

The wish to get into one's car and drive a hundred miles, or go by plane a thousand miles, in order to swim and sunbathe is strong. A purely cultural feature underlies the economics; one can demonstrate this by noting that an Austrian town may have its own swimming pool, indoor or outdoor, perhaps with a sandy area beside it, and hundreds of people walk to it on weekends and do just what their American opposite numbers do by driving 100 or more miles. Will the culture shift in a direction that will spare the biosphere? That is as hard to answer for American sunbathers as for African cattle-herders.

CONCLUSION

What comes out of all this on the relation between population, the economy, the culture, and the biosphere?

1) For the developed countries early fears for exhaustion of resources occasioned by population pressure were largely groundless; economies are free enough and technology sufficiently advanced that the price system will overcome shortages. So here in the MDCs, just where population is stationary in any case, it has the least reason to control its numbers.

2) For the LDCs where now 95 percent of the increase is occurring, exhaustion of lands and food shortages are a genuine hazard. The ability to support population has been diminished by governments that borrowed irresponsibly (for instance in Latin America), that are hopelessly corrupt (for instance in Africa) or that fail to maintain order (again in Africa). Order is threatened also by educational systems that are good enough to arouse expectations, but not good enough to teach productive skills, that generate unemployment as much as they generate production. Under these circumstances population control is an urgent necessity. In just the countries where it is most badly needed it is slowest in coming.

3) The process of development in itself increases pressure on the ecosphere. It does so via the adoption of a culture that increases meat consumption, and so puts pressure on land; that demands factory goods, for which it burns coal and so pollutes the atmosphere; and that travels by automobile and airplane to an unprecedented degree.

4) The developed countries are approaching a high but level consumption of commodities and services with stress on qualitative change, and future quantitative expansion of industry and travel will be through the diffusion of industrial civilization through the LDCs. If there is no world depression this diffusion can be expected to take place at the past rate of 4 to 5 per cent. That is not going to be fast enough to employ all of the educated manpower graduating from schools and universities.

5) On the other hand it is likely to be too fast for the ecosphere to absorb. We see this in the wasting of the thin topsoil of the Amazon, of the floods caused by excessive logging in Thailand, and especially of the changing composition of the atmosphere worldwide.

6) Those who believe that the debts are about to be paid off so that investment can resume everywhere on a scale sufficient to absorb the educated unemployed, that corruption is about to cease, that civil and international wars are finally ending, that forests will soon be replanted and that technology is going to find an answer to the CO2 and ozone problems, these will want to allow population to grow as it will. Those who doubt that these good things are around the corner want to see all possible effort made to reach them AND every effort made also to disseminate the knowledge and means of population control.

TOWARDS A THEORY OF POPULATION DEVELOPMENT INTERACTION

This paper will juxtapose the divergent viewpoints of scholars on population and development, in the hope of contributing to a synthesis of what the several disciplines have to say about the effects of population increase.

Economics has had the most to say. For its first hundred and seventy years of existence as a science, say from soon after Adam Smith to Myrdal, Coale, Lewis and others writing up to the 1960s, it showed how large and growing populations handicap development. During this time there was no major disagreement from others who looked into population. Sociologists took over the field after World War II, resting especially on the increasing mass of statistical data, and they also found rapid population increase a major handicap to development. Biologists had always been interested in the subject, seeing man as an element in the ecology of the planet, and being familiar with instances of species, for instance locusts, that escape their natural checks and increase to the point of destroying their habitat. The several disciplines quoted one another approvingly, beginning with Darwin's report that Malthus had given him the idea with which he could start his work.

This unanimity has been disturbed in the past decade, as some economists claim that after all development is not much hindered by rapid growth (Simon, 1981; NRC, 1986). I will argue that the switch derives mostly from general reading about the resource substitutions that science makes possible rather than from specifically economic data. On this view the case for birth control rests mostly on the right of individuals to decide how many children they are to have, a moral rather than an economic argument, and as such necessarily without any relation to evidence. The administrator who asks a neoclassical economist whether he should give high priority to birth control programs is told no; he then asks a biologist and is told yes. He is left to resolve a clash between disciplines that is too difficult for the experts in those disciplines to resolve.

A population, whether of humans or other species, exists in some kind of setting. Even a population of automobiles cannot be considered separately from the road network, repair facilities, gasoline stations and other elements of the environment in which those automobiles have their usefulness and continue to operate; LDCs in which much more investment goes into the vehicles than in other elements of the system demonstrate this strikingly. The setting for man is a habitat or environment to biologists, the complementary factors of production to economists. We will find that it is their different views of the setting that give rise to the different opinions on population control.

I classify the reasons for population control under four heads, and find them subject to very different considerations. In four words they are resources, capital, employment, and Earth, and they constitute the four main sections of this essay.

LAND AND OTHER RESOURCES

For Malthus, writing at the dawn of the industrial revolution, and not entirely accepting the changes it was making, let alone foreseeing its imminent expansion, the setting was principally land. There was only so much of it and once this was full the further increase of population would have to share it, and hence would have to share the fixed amount of product. Of course this is too simple; the land is never full; it varies in quality from the most fertile to the downright uncultivable, and the more fertile is naturally settled and exploited first. As the population increases it has to move to less productive land, so with everything else fixed it becomes poorer and poorer. Even with the settlement of America, that was prominent in the minds of English theorists at the turn of the 19th century, the limits still applied, though they were farther in the future than in England.

Malthus produced a simple and clearcut theory in 1798, further elaborated over the course of a few decades by himself, Ricardo, Mill and others, on which most secular thinkers—all those who were not bound to an earlier religious or mercantilist view—could agree for the next 150 years.

Energy

As the industrial revolution advanced and the agricultural economy of England gave way to factories, the same concept of limits and scarcity came to be applied to other natural resources than land, and especially to coal. The most accessible seams were being exploited first, so coal would become more expensive, and England's manufacturing preeminence would sooner or later come to an end. Stanley Jevons saw this as imposing a grave threat to the descendants of those then living, and advised that at least the national debt be paid off. What now seems ridiculous (who pays off debts?) made a good deal of sense in the simple world of those times: after borrowing to build a factory one must take out of each year's sales the depreciation, i.e., one must set aside a due part for the repayment of the loan on which the factory was built. It was as though the coal was borrowed and posterity had to be compensated for its use, or at least not left in debt to continue paying for it after it was exhausted. Jevons was an early believer in sustainable development.

But ultimately new sources of energy were developed that had various advantages, and coal mines were abandoned long before their content was exhausted. The succession of fuels—oil, gas, nuclear—along with greater efficiency in their use, along with a shift to less energy-intensive industries, produced a strong impression that the classics had focussed on the wrong problem. It was now the inventive process itself that was the resource—the vision that each kind of fuel would give place to some better fuel, even before it was exhausted. Invention is no longer an accident attributable to genius; it is an established and continuing institution. In all fields of science, but especially in chemistry and biology, the computer so facilitates and automates research that it seems as though progress will henceforth be automatic; now discoveries can be made to order.

Social scientists read the newspapers and choose their theories accordingly.

That perspective was applied to every part of the setting in which people lived and gained their living. We did not need more land, just improved yields on the existing land. Copper, nickel, and other mines would be exhausted, but new sites would be discovered, and at the same time less scarce substitutes would be found. Glass fibers or microwaves would be used in place of copper, being more effective for transmission of signals, as well as less expensive. There was no use going to expense to conserve the forests, for wood was being replaced with plastic for many uses, and paper was better made with cultivated fast-growing trees.

Every week the press carries the news of some impending invention that will dispense with some old material, or at least use it more economically. The substitution is always in one direction—towards the lower cost, more generally available, material: acrylic for wool, corn oil in the form of margarine for butter. And often the substitute is better as well as cheaper. Thus more people require more goods, and so more raw materials of every kind, and while this might disturb engineers who live in a world of fixed proportions, economists bet on flexibility; they show how substitution under the impulse of the price system can adapt to any shortcoming of nature.

Even without substitution a small rise in price will cause more of most raw materials to appear on the market. Higher prices cause people to look more diligently, and they find unsuspected sources—oil in the Arctic Ocean and the North Sea, nickel in a dozen countries where once it was exploited in Canada only. And with higher prices existing materials are used more sparingly: thinner coatings on tin cans, less gasoline per mile of travel, less land per ton of wheat. Now that safety and comfort are taken for granted the

locus of competition among the world's aircraft manufacturers centers on fuel economy.

The Euphoria of Technical Progress

News items on technical wonders are the stuff that fills the press. Today's (December 15, 1988) *International Herald Tribune* reports that a new transatlantic cable has just gone into service, using optical glass fibers, that will be able to carry 40,000 simultaneous conversations in clear and reliable transmission, and that other such cables are under construction, both across the Atlantic and the Pacific. And as for paper, the need for which has been destroying the world's forests, the same issue of the *Herald Tribune* carries the word that *kenaf* is coming into commercial production; it produces a whiter, tougher, more durable paper, that is easier on the eyes than newsprint made from trees. Kenaf makes much more efficient use of earth and sunlight than do the wild tree species for which it substitutes.

The sequence is dizzying. Invention has no limits. The public is elated with the accelerating progress, academics make theories that take it into account, though they claim empirical support on another level.

We are back to the euphoric view of the 18th century enlightenment. Adam Smith was of the 18th century and an optimist—population was self-regulating. But after him economics became known as the dismal science because it said that each increase in production would be nullified by a corresponding increase in population, so the average welfare could not in the long run increase. Malthus, Ricardo, the Mills saw population as setting the limit to progress, though they differed in their estimates of the capacity of people to restrain their fertility. With a different rationale neo-classical economics is now back to Adam Smith, even to the mercantilists; Jean Bodin's "there is no wealth but men" is what Julian Simon (1981) is telling us.

The neoclassicists are captivated by the stream of inventions. The one asset that counts is the ability to innovate—to create new marvels and bring them into economic production. This merging of science into science fiction is the religion of our age, and it would be remarkable if it did not influence economics and social science generally. And in a competitive economy the enterprising innovators to exploit new science will always be forthcoming.

This intoxication with the process of invention became widespread by the 1950s and 1960s. The word "Malthusian" came to mean a narrow, short-sighted niggardliness, a meaning it had always had in France, whose lands were more ample than those of Britain. A Malthusian, as Alfred Sauvy uses the term, is an over-cautious person fearful of apparent limits to resources, lacking confidence in future inventiveness and adaptation. He shows personal timidity in his fear of marrying and having a family.

It is in the realm of food supplies, the original Malthusian limit, that limits are now least believable for Europeans and Americans. Bitter contentions arise among nations on how to dispose of surpluses of grain, chickens, wine and other foodstuffs without causing a price collapse. With their attention mainly on the developed countries, certainly disregarding Africa, economists can indeed say that the shortage of food has been definitively overcome. Similarly with other materials. Think of the 18th century when Britain was running short of firewood; the crisis was overcome with coal. Nuclear energy will supply stationary power; for motor cars fusion and the hydrogen economy are waiting in the wings, with assurances that they will be ready for use long before oil and gas are exhausted.

The sequence of substitutions, starting with fertilizer for land in food production and of synthetics for land in the production of natural fibers seems endless. The evidence of abundance is seen in the market prices of minerals as well as of farm products. The colonial period came to an end just as many of the goods which Europeans sought in the

tropics—rubber, sisal, jute, kapok—were replaced by synthetics. My own sense is that Britain, the most farseeing of the colonial powers, made only token attempts to hold her colonies after World War II, observing that their products were declining in value. Let the former colonial subjects be independent so that they can have the headache of managing economies based on rubber, tin and jute. Why hold on to an economy based on tea when Coca Cola is cheaper to produce and more in demand? Sugar is in glut world wide, and tropical cane has no advantage over beets. The Netherlands did not foresee this immediately, but after forced decolonization they have replaced many of the products of the Indies—rubber, hemp, quinine—with more satisfactory products turned out by modern factories.

Capital and skilled labor seem indefinitely substitutable for land. Hence it looks right to drop the classical "land" as a factor out of the production equation. I will argue that this applies at most to the developed countries, that are concerned about population decline.

The neoclassical economists have found a solution to the problem of overpopulation appropriate to those countries where the problem is already solved.

Each LDC has Its Own Population-Resources Problem, that may be Intractable Even if the World Population-Resources Problem is Easy

The World Bank sums up the matter in its World Development Report of 1984: "The difficulties caused by rapid population growth are not primarily due to finite natural resources, at least not for the world as a whole." The last clause is important; it may be that in a well-managed world the sequence of inventions and their application would provide for any population that is likely to come into existence.

No overall management is in sight. Moreover each of the LDCs has its own problems. Each one needs to be studied to judge how much benefit it would obtain from population restraint. For most the current stream of inventions has brought grave drawbacks; they have felt the bad side of the substitution process, the devaluation of their traditional exports. With a few conspicuous exceptions they do not have the capacity to switch over to modern technology on the scale required. (par) President Sukarno once proposed a ten-year worldwide halt in all science and invention. That is symptomatic, and we should try to understand why many LDC officials do not share our elation with technology.

Certainly the individual LDC is not capable of the research that will accommodate its growing population. The science of the advanced countries is available to it, but the application of science requires organization and capital. In a time when capital is flowing from the LDCs to the MDCs (for the years 1983 to 1987 in the net amount of $93 billions, estimates the World Development Report for 1988, p. 30) investment funds in the LDCs are very tight.

Section 2 will discuss the limits capital sets on the capacity of countries to grow economically at the same time as they grow demographically, and Section 3 will take up the matter of organization, specifically in relation to employment.

A 180 Degree Turn in a Fundamental Principle of Economics

An outsider can well be surprised that a proposition so basic to all economics up to about 1960 has since then not only been qualified but it has been reversed, virtually replaced by its opposite. Those of us who have been looking for some cumulation in social science, especially in economics that has been the most hopeful, cannot but be discouraged by the sudden turn. Were Ricardo, Malthus, and their successors down to Gunnar Myr-

dal dull-witted, incapable of observing the world?

It is the world that has changed. Communication (e.g. television), the conquest of space, computing, the new cellular biology, atomic physics, were indeed changing the world at exactly the time when economists discovered human capital.

Nonlinearity

Even if this was applicable to the LDCs (I will argue that is not) it could be true for the recent past, and yet there may be a hiatus with the increase of scale. The population of Africa is expected to grow about 3 times from now to 2025. We do not live in a linear world, and extrapolation to the future that tell us that Africa's problems will be multiplied by 3 could be deceptive; they could be multiplied by 27, the fourth power of the population.

For an example of nonlinearity as well as nonsubstitutability, consider water. Arid regions depend on fossil water, and in some parts of the world it is necessary to go down 100 meters or more to reach the deposits. There comes a point at which the underground reservoir is used up, and at that point linear extrapolation fails. One need not be an addict of science fiction to accept that the stream of invention will continue. But somewhere there are limits to what invention can do: just as it cannot make space, it cannot produce fresh water on an economic scale. Finding food plants that can thrive on sea water is more hopeful than finding enough energy to duplicate the sun's work of distilling the oceans, but we do not know how feasible that will be. So far turning deserts into tillable land has been possible on a very small scale only. But for the moment let us overlook the uncertainty that nonlinearities introduce and the unfinished business of science.

CAPITAL STILL SETS A LIMIT TO GROWTH

The turn from the dark pessimism of the classics to bland neoclassical optimism was not yet complete by the 1960s. Following the work of Coale and Hoover (1958), it became customary to say that resources set no limit on absolute population numbers, but shortage of capital does. Capital was no longer the loom constructed by the village carpenter, on which the village wives and daughters could weave cloth for local consumption; that kind of home-made capital could not survive in the face of automated looms abroad. LDCs could no longer convert without limit their simple largely rural labor into capital; capital was something purchased from the city, in great part brought from overseas. And the amount that could be bought depended on savings, and savings could be greater for a couple with two children than for a couple with 5 or more. The cost of feeding, clothing, schooling, children reduced the family's and the community's savings. More important than this the grown child had to be equipped with capital if he was to earn a living; the more new workers that had to be so equipped the less funds for buying the new kinds of equipment that would transform and modernize the economy. So it was still important for the LDCs to restrain their reproduction, even if science could produce unlimited resources.

That held for a decade or two, but then neoclassical economics took a further turn that nullified even this reason for controlling population. Savings of households were not important; what counted were undistributed profits of enterprises, and these did not depend on how many children people had. Moreover invention would not only dispense with any limits set by land and natural resources, it would also make capital cheaper. More reliable and more durable equipment, insofar as it lasted longer, could not only save labor but could also be cheaper per year of service. Besides that, many of the gains in productivity in the advanced countries were found to depend little on capital, and much on the operation on the shop floor. Whole warehouses of spare parts could be eliminated by the Japanese "just on time" delivery from the parts plant to the assembly plant.

Such considerations influenced not only public thinking about economics, but also the technical models. Where production functions used to contain land, labor and capital, they now specified labor alone. The skill of the labor was of course important, and the educated labor came to be called "human capital". The implication of this expression is that people can substitute for physical capital. (Yet as Herman Daly points out, a house-builder lacking saws cannot make up for this by hiring more carpenters.)

That seemed to remove the last of the limits to growth. If people—human capital—are the sole agent of production, then there can be no such thing as too many people. With each added person there is the same addition to product as for the previous person. So much for John Stuart Mill's declining productivity as population grows beyond a certain optimum point.

Yet capital does not come so easy to the LDCs. Most have already stretched their credit beyond all caution. What is the LDC debt crisis all about if not that capital is truly scarce? American and German banks counted on the development process to make the LDCs rich enough that they could repay their loans with ease. (They also counted on net imports of manufactured goods from the LDCs to service the debt—that would ruin many manufacturing industries.) What they did not count on was that the rhythm of development is of a lower order of speed than the rhythm of debt accumulation). It was the political pressure to make employment for a growing labor force that as much as anything impelled the overborrowing. That will be the third of my four topics.

I leave the resources question with some question marks, and the capital issue with grave doubts, and go on to two other points that constitute obstacles to population and welfare even if the succession of mechanical marvels is unlimited. One is the capacity to share the work and the product under rapid population increase, the other is the capacity of the planet to absorb the effluents of progress.

ECONOMIC PARTICIPATION OF A GROWING POPULATION

According to the classics there can be no unemployment. Just as the market will reach equilibrium prices that will clear all goods, so it will clear all labor. This law was put in its most unqualified form by Jean-Baptiste Say (1803), and reiterated by virtually every economist up to the 1930s. Thus Alfred Marshall (1930), "The whole of a man's (sic) income is expended in the purchase of services and commodities....a man purchases labor and commodities with that portion of his income which he saves just as much as he does with that which he is said to spend." Each man (or woman) is giving employment with his whole earnings, and the recipient of these likewise; the circulation of goods and money leaves no room for unemployment. In Frank W. Taussig's (1917) words, "The money which is put by...leads equally to the employment of labor (with the money that is directly spent on goods)." Commodity markets look after the disposal of goods, capital markets reconcile savings and investment, labor markets get people into jobs.

Just the same there was long an underground in economics that doubted the capacity of markets to do all these things. J.A. Hobson declared that oversaving results in underconsumption, a thought that is also to be found in Malthus and in Marx. This underground emerged to orthodoxy in the work of Keynes (1936) and suddenly underconsumption was no longer an *idee fixe* of cranks. Because liquidity is desired the market-clearing rate of interest is set higher than the marginal productivity of capital, so will people will try to save more than entrepreneurs want to invest.

Yet in discovering the cause Keynes could point to the remedy: suitable monetary and especially fiscal policies would create demand, raise the marginal productivity of capital, and get the unemployed back to work. For the first time respectable economics assigned governments an active role, far beyond the maintenance of order. By the prosperous 1960s this idea had so taken that economists spoke of "fine-tuning" the economy. With this condition the optimism of Say and Marshall could be restored. Under no cir-

cumstances was unemployment ever a sign that there were too many people, but only of bad policies.

Yet in fact there seem to be persisting mechanisms by which some people are kept out of the economy. In Italy unemployment of the younger age groups reaches 30 per cent, and does not decline even amid the general prosperity. It is true that in Italy there is unexampled rigidity in the labor market. It is so expensive for an employer to dismiss a worker that he will go to great lengths to avoid hiring new employees. Italians talk about the difficulty that youth has to insert itself (*"inserirse"* is the usual word) into the labor force, somehow to come to participate in the economy.

Once in the person is employed for life and at an above-equilibrium wage, so it is almost as though there are two kinds of people—the permanently employed and the permanently unemployed. To an outsider the unemployment of the young is a simple consequence of the old hanging on to their jobs and their high wages, irrespective of competence and diligence, in which they are protected both by the law and by unions. Governments listen to those that are safely in employment, not to those who are trying to get in. Does that prove that there are too many people? I will try to answer this question.

The Wall that Produces the Jobholders

Suppose a city with plenty of land, capital and jobs, and full employment, surrounded by a high wall. Outside the wall are many young people, with no chance of access to the economy within the city because it is the preserve of those already in place. A policy analyst must say in this situation either that the wall should be broken down, or the young people should go away. Either one of these is the solution to the employment problem. Not economics but the distribution of power will decide which happens.

The wall that I speak of is the set of laws, regulations, and practices that include minimum wages, tenure, requirements of admission to professions that have nothing to do with performance. In milder form they exist in the United States, but because they are milder the amount of unemployment they cause is less. They exist in LDCs as well as in MDCs, in rich countries like Sweden as in poor ones like Indonesia. Even where the advantages of a free market are most clearly understood, no one wants his own labor to be disposed by the market, and people agree to secure the benefit of commodity markets without subjecting themselves to the discomfort of labor markets.

In rich countries the unemployed are well supported by the working community, that pays its taxes because it is at least half aware that its own restrictive practices are the cause of the others being unemployed. No one is hungry; in West Germany the unemployed are a substantial fraction of the labor force and receive for long periods State incomes that are 80 per cent of what they would earn if they were working. The community apparently prefers to arrange things so that a part of it is working and supporting the other part, rather than all of it working shorter hours. (The unions place impossible conditions on any proposal to share the work; their condition for a 35-hour week is in effect an immediate increase of 15 per cent in the hourly wage.)

It is also argued that the consumption of the unemployed is needed to keep up demand. If the unemployed all went off to some other country some of those presently employed would lose their jobs. This argument is incorrect. The taxes levied for the support of the unemployed could simply be paid to those working, who would increase their consumption accordingly. The unemployed have indeed a function as consumers as things now stand, but this function would willingly be taken over by those who are working. In fact everything would be much simpler; the taxes to support the unemployed would simply not be collected but spent by the taxpayers themselves.

If nothing can tear down that wall protecting the jobs of the people who are in the labor force, then is the excluded population not in excess of the needs of the walled-in city? And would the people in the city not be better off if they did not have those people

on their conscience and on their welfare rolls? And is this not a case for birth control? I submit that the sight of the unemployed, of what looks like superfluous population, is one of many factors that act back on the willingness of parents to have children.

In the LDCs

It is in poor countries that the employment problem becomes grave. Powerful political forces make laws that give the employed a permanent hold on their jobs. Once a young man or woman is appointed assistant in an Indonesian university (that can happen before the B.A.) and holds on for one year, he or she has the job for life. There is no force or accident that can remove him—no amount of incompetence or failure to perform makes an acceptable case for dismissal. One dean I know tried to install a rule that the teacher had to show up on the campus at least once a month or he would lose his tenure; the attempt failed.

Everywhere the concern for those who have jobs takes precedence over using the abilities of those who are out. The unwillingness to allow an untrammeled labor market in the formal sector does not lead to the comfortable leisure that is unemployment in Europe, but to an informal sector in which a high percentage of the labor force maintains itself—that is a truly competitive underclass. Above it is a formal sector that is even more distant from the competitive labor market ideal than is West Germany. That the countries that are prospering—the NICs—set the example of free markets does not influence their poorer neighbors. Deregulation has not so far had any impact on employment.

The result is a pervasive hopelessness of youth in LDCs everywhere from Egypt to Mexico to Indonesia. Not a day passes but one sees in the press the political pressures that this builds up. Speaking of North Africa, *The Economist* (Nov. 26-Dec. 2) says, "Runaway growth of population, and of cities, has placed time-bombs all along the southern coast of the Mediterranean. The streets are filling with unemployed, frustrated youngsters. To keep them quiet, governments cling to subsidies and price-controls, which make things worse and prevent job-creating growth." One has to believe the unanimous judgments along the same lines of observers from 30 or 40 countries. What is reported is a dangerous interaction between the new generation, produced by the high fertility and low mortality of the last 20 years, on the one side, and the rigidity of the labor market on the other, with its consequences for economic policy and ultimately for political stability.

Young people attend university in the hope of qualifying themselves for entry into the protected job market, and when they finish they cannot be placed. They go back to school with the thought that a further diploma will enable them to scale the height, and moreover the time they lose by further schooling is not worth much anyhow. The situation is sadly reminiscent of North America in the 1930s.

In this situation social order becomes a national preoccupation. It is this as much as anything that makes authoritarian rule an unavoidable stage of development. Those countries where there is not firm rule are upset by riots and threatened riots.

When the existing job holders are protected the private sector is reluctant to take on more people than it absolutely needs, so recruitment in the entry occupations falls off, and this affects mostly the young. In countries where there was a huge increase in births surviving past infancy starting in the 1950s and 1960s, i.e. in practically all of the LDCs, the number of youth that this effects is numerically overwhelming. Add to that the rapid expansion of education in the 1970s, so that the young people left out are better qualified than their elders who have jobs, and one starts to have an idea of the potentially unsettling consequences of recent population growth.

Try to tell the administrator of an LDC that has extended its credit to the limit that physical capital is not important for employment, that human capital is alone what counts! He sees the shortage of real capital as an absolute barrier to employment, to income, and ultimately to social stability. In today's issue (December 16, 1988) of the *Jakarta Post*, the lead article on the front page is the report of a speech by Radius Prawiro, the Minister for Economic Affairs. He puts the matter simply: "At home," he says, "our biggest problem is to create jobs for the steadily increasing labor force." And then, "Jobs can be created only by increasing investments."

The LDCs Want Birth Control; Are They Ignorant of Their Own Needs?

Some have said that the LDC authorities are pursuing birth control only because westerners have urged them to do so. That gives far too much credit to the westerners—I personally can provide assurance that we do not have that degree of influence. The drive for birth control comes from within the LDCs, and the employment problem is mentioned far more than any other as the reason. Next to that comes natural resources. The arguments cited in Section 1 showing that resources set no limit to population apply at most to the world as a whole. Poor countries that lack capital by no means see their salvation in a chain of inventions that will overcome their limits of land and minerals.

I have discussed three aspects of the need for a limit on population. Resource substitution depends on technological capacity that is much harder for poor countries than for rich ones. Capital is available in rich countries; it is desperately short in poor ones. Unemployment, in the sense that they have no access to the jobs for which they have been trained, is increasingly a problem in the LDCs and makes further additions to the population dangerous for civil order.

If these three problems were overcome, could a larger population than now exists flourish in the LDCs? No. We come to a fourth problem that no likely technical advance and no amount of capital that is in sight can dispose of—a universal national problem that is also a global problem.

HUMANS HAVE BECOME A LARGE-SCALE GEOLOGIC FORCE

The title of this final section is due to V.I. Vernadsky, the Russian geographer writing in the 1920s, as quoted in SSRC (1988). Thus "human activities are now inducing change on a scale comparable to the natural cycles of the earth." The SSRC speaks of "the erosion of soils, the pollution of the air of cities, the hazards of earthquakes in built-up areas, the genetic dangers of biochemical control of weeds and pests, and the longterm menace of rising global mean temperatures" and complains that these concerns have not sufficed to bring social scientists into the needed research endeavors.

The Economy Exists Within a Larger Setting

Certain future events now coming into view are not provided for in any economic or social science model. The economy is set within the ecology, surrounded as it were by the ecology, influences the ecology and is limited by the ecology. Perhaps because they were closer to nature than contemporary social scientists, the early economists never forgot the habitat within which the economy sits. Alfred Marshall considered biology the natural science to which economics ought to be closest, but since his time that is not often heard.

Nonacademic observers of today come closer to this theme than do social scientists. Thus a recent issue of *The New Yorker* (August 28, 1988), at the beginning of its "Talk of the Town," speaks of "the decimation by air pollution and acid rain of the forests along the crest of the Appalachians; the presence of so much floating sewage (some of it medi-

cal) on the edge of the Eastern Seaboard that long stretches of public beaches have had to be closed; a drought so far-ranging and sustained as to qualify 40 per cent of the counties in the United States as disaster areas; and, worldwide, the hottest temperatures in the hundred and thirty years that anyone has been counting." (Four of the hottest years of the century have come in the nineteen eighties.) Extensive and more professional accounts of such limits of the capacity to sustain population can be found in Barney (1980), Ehrlich (1970), Meadows (1972), and Clark (1988).

Warming of the Biosphere

At any given level of living, and with given technology, the amount of automobile emissions, the amount of water used, the amount of oil consumed, will be proportional to the population. As Kingsley Davis has reminded us, it is people that produce and consume these things.

And it appears that the planet can stand only so much of these products of the economy. James Hansen, head of NASA's Goddard Institute for Space Studies, testifying to a Senate committee on the hottest summer in the hundred and thirty years of the record, said that "it is time to stop waffling ... and say that the evidence is pretty strong that the greenhouse effect is here."

Other writers have expanded on the effects of the warming, some positive, some negative. The strongest negative effects will be on rain-fed agriculture in the LDCs (Gleick, 1988). Many existing agricultural lands in the US and the USSR will become desert, while the more northerly parts of these two countries, and of Canada, will benefit. The Arctic could become open sea for at least part of each year. The oceans would rise, both because their waters would expand on warming, and because of the melting of the polar ice caps. Flat coastal lands would become very vulnerable to storms, in the way that Bangladesh already is. Many of the international river basins would suffer reduced flow, and this would contribute to disputes among the riparian states on the division of the smaller amount of water.

On an optimistic assessment there could be no net effect—the good results of warming would be just equal to the bad. Even in this unlikely case the world still faces an enormous problem. For the distribution of population over the face of the earth has evolved in some sort of rough relation to the productivity of soil and climate in the various parts. Over most of human time those parts of the planet whose soil was more fertile tended to have more people. We need not exaggerate the correspondence, for many other factors entered, and there are many cases, as Ester Boserup tells us, when it was not the fertility of the soil that created the people, but the exceptional effort of people that made the soil fertile. Still, starting from the present baseline, one can imagine the dislocation if the grain output of the USSR were to double at the same time as that of India and Africa were to drop by 50 per cent.

Sustainable Development and Ecological Borrowing

That the economy is set within the ecology is recognized in the concept of sustainable development, vague and undefined perhaps, but now so respectable that the United Nations has a book on it, with others coming. In the titles of these books appear such phrases as "Waste Water Management", "Airborne Sulfur Pollution", "Potentially Toxic Chemicals".

These and other hazards are charges against the economy, though not calculated as such. To exorcise them will require effort and expense, and much of that future expense will pay for income that we have already enjoyed. In short some of our past income was borrowed; we were not and are not as rich as we thought. Whether it is damage to the ozone layer that we must seek to repair (though no one knows quite how) or poisoned

streams, or dying forests, there will be some sacrifice in the future—either we will have to pay to clean or repair them, or else the damage to them will make production more costly in the future (as in the loss of forests), or else there will be sacrifice of amenities.

In the words of the Brundtland Commission (WCED 1987) "sustainable development is that development that meets present needs without compromising the ability of future generations to meet their needs". We are not any the less borrowing because we are ignorant of the amount of the loan. For some kinds of borrowing estimates can be made. Malcolm Slesser and Jane King (1988) have done something in respect of energy.

Perhaps an estimate can be made of the cost of cleaning up rivers, because that has actually been done in various parts of Europe. But the cost of forest dieback is going to depend on success in finding substitutes for wood. Nothing can replace the forests in their function of absorbing carbon dioxide. Nor is there any way to reconstruct the varieties of cultivated plants that have been abandoned, nor the wild plant and animal species that human activities have rendered extinct. It would be an anticlimax to discuss the general untidiness that goes with progress. Americans have a high tolerance of beer cans, bottles, and old newspapers on the streets, and abandoned refrigerators and automobiles in the woods. Europeans do not like these things, though with further advance of their economies they may get used to them.

The point is relevant to the present argument in that it is people who produce carbon dioxide and destroy the forests of the Amazon to gain (not very long-lasting) farmland. At the present time the number of those who drive motor cars and otherwise live a middle class existence is about one billion of the 5 billion on the planet, and it is this billion who threaten the biosphere. We may construct a scenario that will help visualize the "geological forces" impacting on the planet with the 8 billion people expected by 2025, if all of them are middle class.

CONCLUSION

After more than a century and a half in which generation after generation of economists proved that a large population was deleterious to development, the discipline went into reverse in the 1970s and argued that population does not make much difference. Whatever the overt argument for this, its real justification is that the march of science and resulting economic innovation permit a substitution of common resources for scarce ones, so that resource limits to population have largely disappeared.

This reversal of economic theory exactly corresponds to the reversal of the population problem for the developed countries—the one fifth of the world world that is facing population decline. The French, the English, the German and the American publics readily agree—they have been saying it themselves since the 1960s—that the issue raised by Malthus is decreasingly applicable to them. Neoclassical economics has indeed indicated the solution to the problem of too many people—applicable to the countries where the problem no longer exists. (I optimistically disregard polluted streams, forest dieback, and a corrosive atmosphere in many places, supposing that the wealth of Europe and America can clean these up at the present levels of population.)

The less developed countries contain four fifths of the world population, are responsible for 9/10 of present population growth, and can expect 100 per cent of the world's population growth as the century comes to a close. They do not have the spare land, or the capital, to accommodate their burgeoning citizenry. The demand for their raw materials constituted the economic basis on which they started their upward course, and now the science of the developed countries has invented substitutes that undercut that economic basis.

One could say that the LDCs are in the position that the MDCs were in when Malthus, Ricardo, Mill and the other great economists lived, except that the position of many is much worse. Not only do they face resource limits as our ancestors did, but their populations are orders of magnitude greater, and they have installed systems of mass education that give their young people expectations incompatible with available resources and capital. Their students do not obtain from college the skills of the best western engineers and scientists, but one thing they do get from college: the highest of expectations. The LDCs could not fully employ their young people when their net borrowing was at its peak; what about now when they are paying back?

The last thing they want or need is the prospective further growth in their unemployed youth. They see a birth today as a young man or woman with a high school or college diploma in 2010, unable to get the job for which he or she was supposedly trained.

Our science, that has produced the substitutes (for rubber, sisal, cane sugar) from which their economies are suffering, affects them very differently from the way it affects us. They do not have the high level scientific manpower to understand, import and apply it, let alone to discover new science that will be appropriate to their particular problems. And even if their educational systems produced young people with the knowledge and skill that was consonant with their expectations, as their debt service increases they have less of the capital that would enable them to put that knowledge and skill to work.

That is why they see the neoclassical view that the population problem is essentially solved as a monumental ethnocentrism.

So much for the first three points of my argument. Let me offer a scenario that will clarify the fourth point. It is improbable but not inconceivable, the endpoint within the first quarter of the 21st century of a trend that is already visible in 1989.

A FINAL SCENARIO FOR PLANET EARTH

Suppose that by 2025 the economic problem is everywhere solved (Keynes' (1932) expression) in the sense that GNP per capita is growing at more than 3 per cent per year and either there is full employment or the unemployed are comfortably supported on social security. All of the standard indexes indicate unprecedented prosperity.

Meanwhile the atmosphere is warming and rainfall patterns are changing, deserts are continuing to spread at the same rate as in the 1980s and have come to cover the larger part of the planet, water tables everywhere are falling, holes in the ozone layer are rapidly increasing cancer deaths, locust and other pest outbreaks are more and more frequent, all the tropical forests have disappeared and the last of the boreal forests are threatened. Among other irreversible changes half of the plant and animal species existing 50 years earlier have become extinct.

As has always been the convention, GNP can continue to rise because it is calculated gross of all depreciation; for national income the depreciation of plant and equipment is netted out, but not the deterioration of nature. The greater part of the very high national incomes has to be spent on disposing of wastes, on replanting of trees, on transporting water, on making dikes against the incursions of the oceans, on fighting pests, on restoring soils. These are all entered on the plus side of the national income, but the deterioration that they are (partially) correcting is nowhere subtracted. National accounts measure the sustainability of our activities insofar as they depend on plant and equipment, but make no pretense of measuring sustainability insofar as they depend on nature. With other things fixed, every one of the unmeasured negative elements mentioned above is related to population.

In this scenario people would feel poorer and poorer, despite the assurance offered by the steadily rising income per capita.

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