Population and Resources

Daniel B. Luten, Jr.
University of California (Berkeley)

ABSTRACT: Rapid growth of the world's population is recent. World food production has increased in close proportion. No one can say when or in what fashion population growth will end; whether by our deliberate choice, or by catastrophe, or by some limit of the Earth.

In the United States, during a century and a half of rapid growth, farming has diminished from being the major economic activity to an almost trivial fraction. At the same time, farm production has increased many-fold. One result is that the American public spends a smaller portion of its income on food than, probably, has any society in human history. Not all of the world has shared in this agricultural revolution and, once in recent decades, and now again, evidence suggests food production may fail to increase with population. Certainly no guarantee can be offered that food production will always be adequate.

Pessimism on the outcome is warranted if only because of profound disagreement among those who should be best informed. Many look only to the near future and persistently advocate growth. Only a few look to the long-run and the inescapable disasters of persistent growth.

RETROSPECT AND RECOLLECTION

We live in an age of change. At times it seems that accelerating changes may have no limits or, alternatively, that we approach some condition where growth is unmanageable and everything collapses. It was not always thus. Far more representative of human history and, even more, of biological history, is the situation where, symbolically, the world (if not the village) into which a man was born differed imperceptibly from that from which he died.

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Please address correspondence to Dr. Luten, 1097 Creston Road, Berkeley, CA 94708-1545.

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Let me suggest some examples:

1. My maternal grandfather, whom I knew well, was born a few weeks before John Muir, in 1838, a century and a half ago, into a world of one billion human beings.[1] He outlived Muir by a dozen years, dying shortly before my graduation from college in 1929 in a world of two billion people. When I gave up chemistry for geography in 1961, the world's population was three billion. When they retired me from active teaching in 1975, it had reached four billion. A year or two ago the number reached five billion, three billion in East and South Asia from Korea and Indonesia to Turkey, one billion in Africa and Latin America, and one billion in Russia, Europe and Anglo-America.

I doubt if my grandfather ever heard any serious mention of the issue of world population growth, 77% in his lifetime. But he knew of change: he was born just behind the frontier in Indiana in a still forested land where travel was on foot, horseback or, rarely, by canalboat or stagecoach. He lived to be familiar with interurban car and railroad travel, to see, now a century gone, the end of the frontier. He was accustomed to automobiles but not to thinking of them as a utilitarian household tool. He knew of airplanes but never flew. He must have known of the growth of the American population: it was seven-fold, from 16 to 120 million in his lifetime. Finally, while not a farmer, he was involved with farming.

Figure 1 is titled, "Oats harvest, break for dinner, 1905." The location is northwestern Indiana, a hundred miles south of Chicago. Forty-four people, by my count, appear in the photograph; thirty of them look as if they might have been farm labor. The others, women and small children, were providing meals or learning about all of these things. The one elderly man, he is to the left, is my grandfather, then aged 67. He looks older by our standards; life was not as easy as for us. In *Figure 2* (the focus is not as good), we see the steam engine, mobile but barely so, providing power by leather belting to a thresher fed by hand from horse-drawn wagons. Fourteen men and at least eight horses are visible. The wagons are coming in from the field loaded with oats; a great pile of straw and chaff is in the background.

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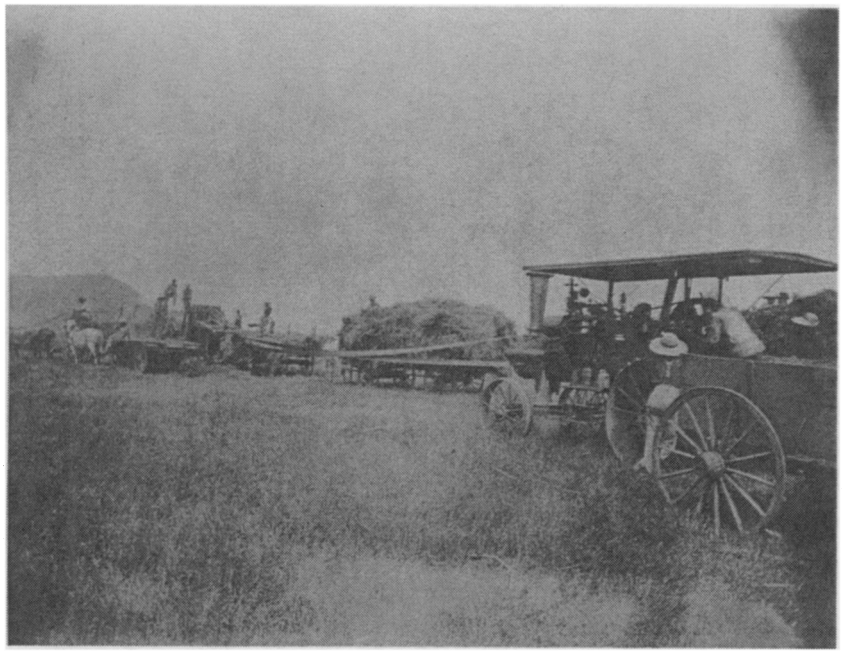
[1]Values used in this paper for historic world human populations are taken either directly or by linear interpolation from Bennett (1954, p. 9), whose values stem from the classical inquiries of Carr-Saunders, of Beloch, and of Willcox. Data for more recent world, American, and American farm populations, for American farm animal populations, for petroleum production, and for foreign trade come from either Statistical Office of the United Nations (variously from 1948 to 1972), or U. S. Department of Commerce (1975), or U. S. Bureau of the Census (variously from 1947 to 1989). Data for crop acreage, production, exports and fertilizer usage, come from the above or from U. S. Department of Agriculture (variously from 1963 to 1988).

FIGURE 1. Oats Harvest, 1905: Break for dinner.

FIGURE 2. Oats Harvest, 1905: Steam engine and loaded wagons



In that year, 1905, the nation's population was about 84 million and the farm population was about 31 million (37%); each farm laborer produced food for 7.1 persons, only one of them foreign. The horse and mule population was 22 million; the oats production was 1.1 billion bushels from 33 million acres and it might have provided close to half (45%) of the nutritional requirements of the equine population.[2] These proportions had changed but little since 1850, the first year for which I find numbers, when the farm population of 23 million was 44% of the national total of 50 million.

Figure 3 shows the farm in 1986; it is the same farm, the house is unmistakable. One man is combining soybeans, a crop barely known to us

FIGURE 3. Farm, 1986: Soybean harvest

[2]Assuming 1500 pound horses, 138 pound people, 3000 Kcal/day/capita for people and 0.75 power rule for metabolic requirements versus weight: this gives 6.6×10^6 Kcal/horse/year; oats at 412 Kcal/100 gm and 32 lb/bu (Ackerman/Luten, 1949, pp. 144, 532) gives 59,800 Kcal/bu; 22 million horses (and mules) $\times$ 6.6 $\times$ 10^6 Kcal/horse/year $\times$ $^{45}/_{100}$ divided by 59,800 Kcal/bu = 1.1 billion bushels.

in 1905; his twin brother is bringing a truckload into the farmyard to unload into a storage bin. The two of them farm the same land as in 1905 (560 acres) plus close to another thousand acres with no other labor on the farm. In 1986 the nation's population was about 242 million; the farm population, 5.2 million, was 2.1%. Farm production was vastly greater in 1986; the skill of the labor force, both human and equine, had been replaced by machinery, its energy by petroleum.

2. Next, my father, the son and grandson of Dutch immigrants, the first of his line to make it to college, of course chose engineering, a practical art. He once confessed that not merely was he required to pay his own way in college but also to earn the wages of a hired hand to take his place on the farm. He taught engineering briefly at Purdue, probably disliked it and quit in 1900 to build bridges. Each of you must have crossed at least one of the some 13,000 Luten Design concrete arch bridges in North America, some quite large, many small. The world's population did not double in his lifetime (2.3B/1.32B, 82% increase). He had heard of some of these matters; I find a copy of Raymond Pearl's *Biology of Population Growth* (1925), in his books but do not recall his mentioning it.

3. In contrast, in my lifetime, the world's population has tripled. *Figure 4* suggests how the numbers have changed in our sesquicentury compared to earlier times, compared to the world known to James Watt, to Sir Isaac Newton, to Galileo, and to Caesar Augustus.

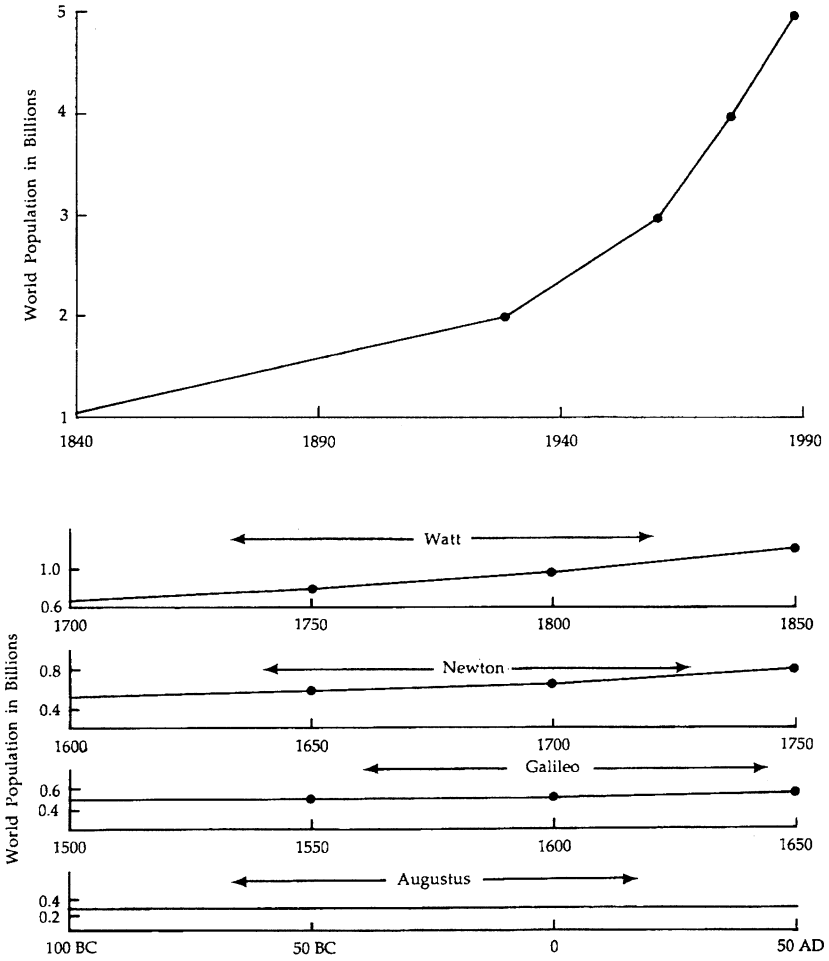
Now, a few comments on other sorts of change:

1. My grandfather was a hunter, He had, in the late nineteenth century, a hunting shack in the Kankakee marshes, right where the Monon Railroad crossed the Kankakee River. He told me of seeing the courtship dance of whooping cranes in the marsh. He told me of shooting diving nighthawks to improve shotgun markmanship and he rebuked me, aged fifteen, for impertinence when I said that it seemed a poor sport where you did not even pick up the quarry. You see, my high school biology teachers had already been at work on me. And that is another element of change!

Today, the Kankakee marshes are gone, the River is little more than a drainage ditch, the Railroad is long since bankrupt, the whooping cranes are slowly recovering from a mighty close brush with extinction.

Someone, Loren Eiseley or Aldo Leopold, I have not found the exact quotation, has observed how fascinated, ecstatic even, we are at the great outpourings of animal life that were so familiar for millennia to our remote ancestors and of which such small residues remain. Why, indeed, do we go to the Serengeti plain? On this continent, where they once swarmed, the passenger pigeon, the Carolina parakeet are gone, the American Bison well nigh so. My grandfather might have seen impressive, if declining examples

FIGURE 4. Population Change from the Time of Caesar Augustus to Present



of these. What have I seen of this nature? Mayflies![3] Nonetheless, mayflies are better than nothing at all and, as a childhood collector of such critters, I was thrilled to come upon such an event at least once in my life.

[3]The oral presentation of this paper included color slides showing a mayfly "hatch" from the Mississippi River near the Wisconsin-Illinois border in August, 1974. The number of insects, estimated in the hundreds of millions, burdened roadside foliage for a few miles and at its densest was a cloud so obscuring visibility for a few hundred yards as to bring traffic to a walk. Black and white prints from the slides quite fail to give a convincing representation.

2. In 1946, at the close of World War II, the United States produced two-thirds of the world's crude oil and was an exporter. Today, while producing 75% more than then, we meet only half of domestic consumption from our own production and our production is but 15% of the world's total. Such is the fate of pioneers in resource development!

3. Around 1905, we exported 100 million bushels a year, perhaps a seventh of our wheat production, and little of other grains. In recent years, exports of grains and oil seeds from the United States have been thirty-five times greater, comprising for a few years the major portion of such goods in international commerce. These recent exports have been the product of nearly a third of our harvested cropland (Luten, 1986, p. 61).

4. We have changed from an agrarian, through a construction and manufacturing economy, to an economy in which services approach primacy, in this sesquicentury. Finally, within the last few years, we in the United States have come on a new turn of events: our balance of payments has reversed and we have become a debtor nation. I suspect this is the natural fate of pioneer service economies.

PROSPECT AND SPECULATION

Inevitably we know less of the future than of the past. Our concern with each is a testament to our humanity, to our difference from, perhaps to our superiority over our fellow travellers in this immense journey. Projections, predictions, forecasts, all assume some continuity or specific discontinuity from the past into the future. Prophecies I take to stem from divine knowledge of the future. I know of no recent prophets.

Projections, as Garrett Hardin has noted, come in several kinds and with disparate purposes. I classify them as (a) self-fulfilling, (b) self-defeating, and (c) ivory tower. The first, in a sense optimistic, hope that what they project will come to pass; the second, in a sense pessimistic, hope that what they project will not come to pass. The third, unpublicized, either do not care or know that no one is listening.

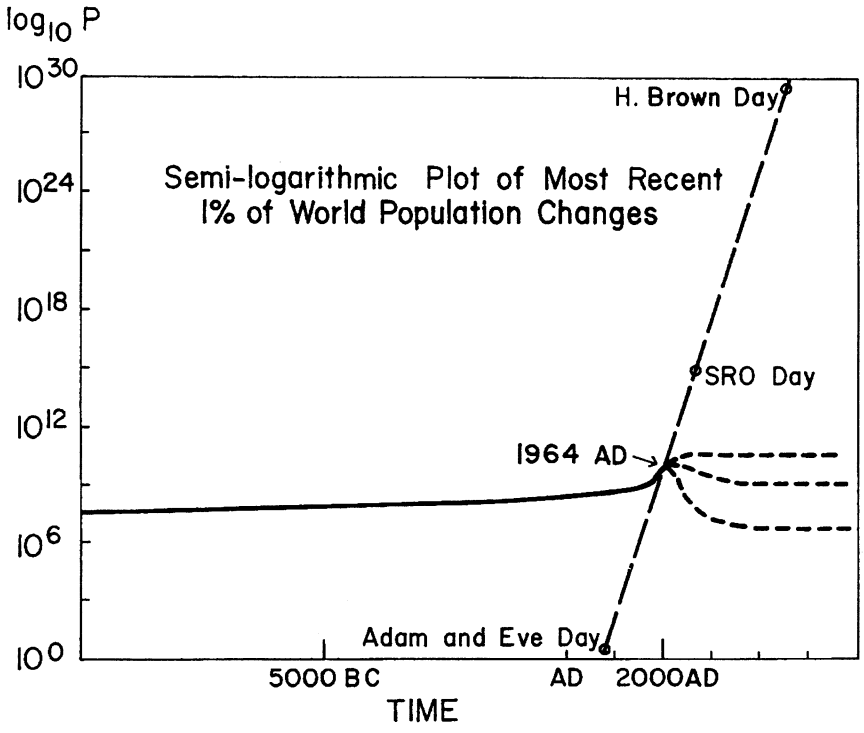
Projections also come in diverse scales, both of time and number. Thus:

1. Robert Malthus, (1960, p. 27 ff.), read carefully, said that food production in 1988 would not be more than seven and a half times what it was in his day, 1800, and in consequence that the world's population would not be more than seven and a half times what it was in 1800. In fact, we think it was about 900 million in 1800 versus five billion in 1987, an increase of but 5.5 times over 1800. Although social scientists widely proclaim Malthus disproven, the numbers do not support the allegation.

2. Raymond Pearl (1925, p. 173) thought the world's population growth might end with an additional 300 million. He thought human population growth just as bound to a logistic growth pattern as fruit fly populations, although he did see the possibility of successive cycles of logistic growth as, perhaps, new worlds, new technologies might open new opportunities.

3. Some are long term. Thus, Harrison Brown[4] (*Figure 5*) is commonly credited with suggesting that if current growth of about 2% annually were to continue for two millennia, the earth would be a mass of humanity expanding outward at the speed of light. Six hundred years along the way, we would pass the standing room only (SRO) population, 10^{15} people, five square feet per capita, land and sea.

FIGURE 5. Population Growth: Extrapolation to "Harrison Brown Day"



[4]See, however, Palmer C. Putnam, cited in Bennett (1954).

Some have suggested that we might colonize the planets and I must spend one minute to skunk that idea: I am willing to concede each of the planets to be as hospitable and accessible as earth, provided my antagonist will concede for simplicity and arithmetic symmetry that growth is at 2% annually, that only eight planets exist and that a time will come when we can agree Earth is full. Henceforth all growth will be on Venus. How long to fill Venus? Thirty-five years. And in a second thirty-five years? Mercury and Mars. And in a third thirty-five years? The outer four planets. It hardly seems worth the effort.

4. Charles G. Darwin, (1952, p. 146ff), in *The Next Million Years*, thought that any human society that succeeded in limiting its numbers would inevitably be replaced by one that could not. We might reflect on current illegal immigration into the United States.

5. Practical men dismiss such talk as visionary and argue simply for growth in our time. It is reminiscent of Neville Chamberlain's "peace in our time . . . Go home and get a nice quiet sleep" (Bartlett, p. 843). That is, with luck, we shall die before we must face disaster.

One pattern, pervasive enough in the past to have some predictive value, is the demographic transition, from the so-called "Malthusian" society of short life expectancy, high birth and death rates, slow growth and wide-spread poverty, through a transitional condition of declining death rates, rapid growth and improving living conditions, to a "western," meaning European, society of low birth and death rates, long life expectancy, slow growth and substantial affluence. It is commonly represented graphically as a plot of birth, death and growth rates versus time of, say, a century. Alternately, in *Figure* 6, life expectancy (LE) in years is plotted against birth rate (crude birth rate (BR)) in numbers per 1000 per year. If, now, a society is in a completely steady state condition, no growth and no vital rates changing for the past several generations, it will fall on the hyperbola: $LE \times BR = 1{,}000$. If it is also Malthusian, it will fall in the lower right corner; if it is western, in the upper left. The points are for 1973; space exists for only a few names. Nothing is in the Malthusian corner but a good many societies are in the upper left corner and may be heading for sites on the curve. The great host of transitional societies, so many of them African, can be thought of as heading northwest by one route or another. The closer the point is to the hyperbola, the less, probably, is its growth rate and, most important, the faster the transition might occur. In contrast, one wonders if all of these on the outer limb will, in fact, succeed. Or will they fall back to a Malthusian condition because of excessive growth?

Figure 7 shows how matters have been changing, over the interval from 1973 to 1990, in the seventeen national societies with over 50 mil-

FIGURE 6. Demographic Transition, 1973 snapshot

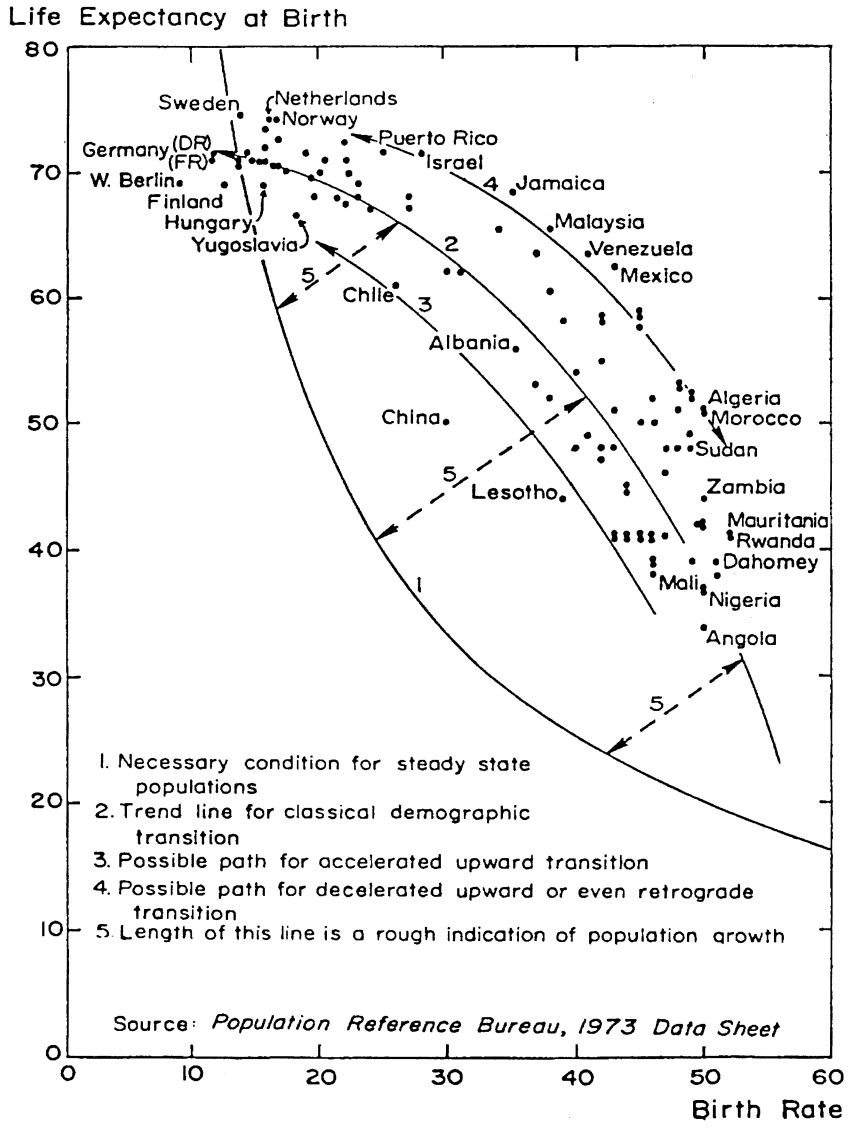
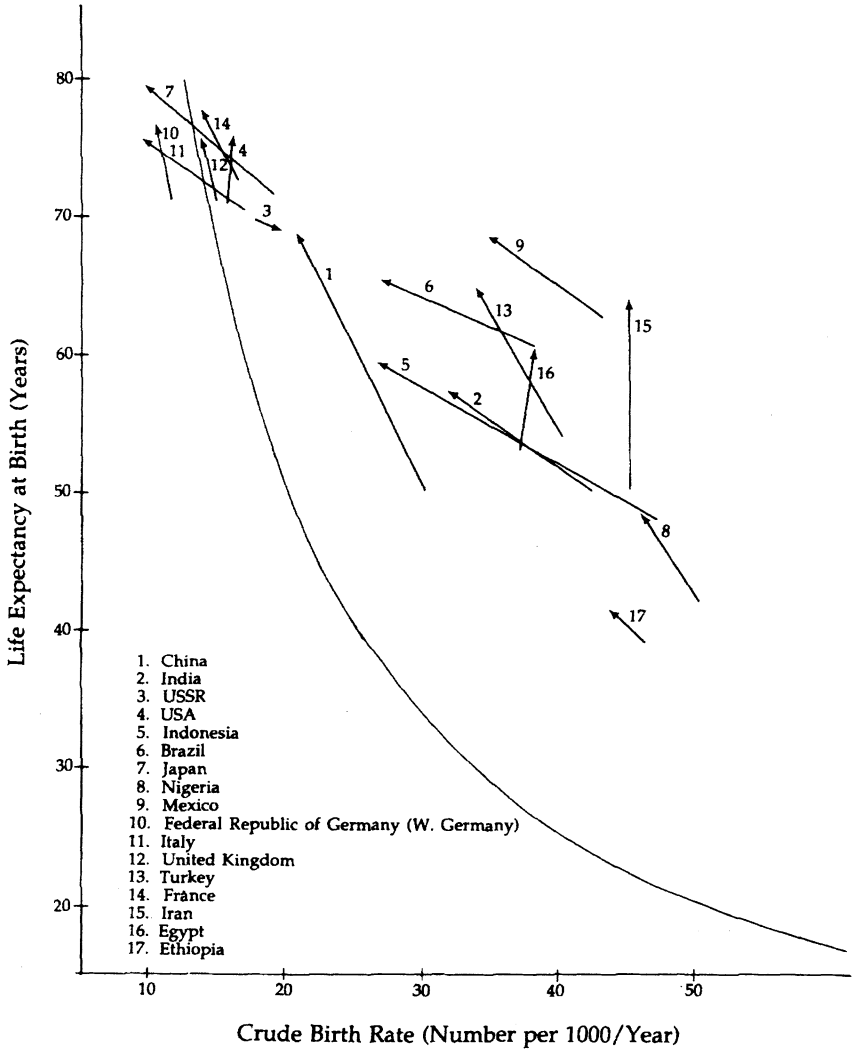


FIGURE 7. Demographic Transition, 1973 to 1990



lion population and for which adequate information is available in my sources (Population Reference Bureau, 1973, 1990). These comprise two thirds (68.2%) of the world's population. Data are insufficient to include Bangladesh, Pakistan, Philippines, Thailand, and Vietnam.

What comes out of this, and other matters I have not had time to mention, in the way of predictive rules is precious little:

1. Growth, in the long run, must be transient.
2. Physiological limits set a ceiling on human population growth rates.
3. Food must be sufficient for each person to eat fairly regularly.
4. In the short run, we project existing trends and hope for the best.
5. We do apprehend warning signals, if slowly, and do change our ways. Laws for fruit flies (and for mayflies) do not adequately describe human reproductive conduct.

THREE PARAGRAPHS ON ECONOMICS

Economists damn outsiders for aggregating, for lumping too many things together. But economists tend to look at the dollar side, the yen side, of what is always an exchange of disparate goods and services for money or credit. By doing so, they conceal an enormous aggregation, an enormous lumping together of widely different sorts of goods and services. One matter that comes out of this is that natural resource commodities amount to very little in the American national accounts. Why, then cannot we simply do without activity in this economic sector altogether and be rid of the entire problem?

Now, another element: each person on Earth has, on the average, available to him the productive capacity of one person, increased by some accumulation from the past and diminished in a sense by accumulated depletion of natural resources. If, today, the United States have an adverse balance of payments with the world, it means that we are letting some very hard-working foreign people support us with their goods. But they do wish payment and the only real payment we can give them is ownership of what we ourselves owned in the recent past. The new owners will also wish us presently to pay rent on what they own here; the only way we can do that is to sell them more of what we now own or, alternatively, to redress that adverse balance of payments by sending them more goods and services than they send us.

Excepting one possibility, to be mentioned next, I suspect our only way out will be to institute a barter system of trade with rationing of imports to insure that we do not import more than we export. Alternatively, will we say that this is a problem for tomorrow's children? After all, what have our grandchildren ever done for us?

NATURAL RESOURCES

First, a classification scheme:

1. Stock resources
   a. non-energy minerals: physically limited but durable and, in some

degree reusable, recyclable. None of it leaves the Earth, but much is diluted irretrievably.
   b. fossil fuel: physically limited and its latent energy when converted, ultimately, to heat, is lost to the skies.
2. Flow resources
   a. fresh water: use it as you will, more will appear; but the volume may be quite limited, regionally.
   b. solar energy (and wind, etc.): use it or not as you will, more will appear; there is a ceiling on how much but it is remote.
3. Regenerable resources
   a. forests, fisheries, wild game: an overt "productive inventory" is essential to production; once lost, as in an extinction, and the resource is gone forever.
   b. agriculture, where the location of "productive inventory," whether soil or seed, is a bit foggy, so let us keep it separate.
4. Assimilative resources: the capacity of the environment to absorb, to dilute, to neutralize the insults, the environmental contamination we visit upon it: sewage in the water resource; smog in the air; garbage in the earth; visual blight and litter; noise, stench, radioactivity and persistent pesticides. One could argue it really belongs in several elsewheres, but little is gained by trying to identify them.
5. Reserved landscapes: nature parks, wildlife refuges, wilderness, and their biota.

My focus here is on the United States and on agriculture. Our invasion of this north temperate New World was fast beyond all human precedent. Everything happened faster here and we have become addicted to growth. We have fished it out, trapped it out, shot it out, cut it out, drilled it out, mined it out—except for coal. While we have plowed some of it to ruin, a great deal of fine cropland remains. About all that is left in great abundance is coal and cropland. I wish to say a little about the latter.

Warren S. Thompson (1949), early American demographer, author of *Population and Peace in the Pacific*, once told us, "There is only one Mississippi Valley in the entire world. No other agricultural realm faintly resembles it in the extent and quality of good soil, good temperature, and good rainfall."

But, our economic system beats it down, perhaps exactly because it is such a great resource. We condemn its owners, managers, especially its labor to a lesser class. We pay farm labor, some of it highly skilled, $5/hour while a metropolitan attorney gets $150. Does the latter contribute so much more to our society? How much does the farmer get from a loaf of bread? Six cents. How much do we spend for food? Thirteen cents of each dollar. What is the farmer's share of that thirteen cents? One-fourth, say, 3% of national income. That is his gross return, not net.

The economists might say it is the farmer's own damn fault; it is the veritable proof that he is the efficient link in the food chain. And, certainly, farmers do bring much of it on themselves: thus, in their eagerness to get into farming or to expand their operations, they bid up the price of land so much that their net return on capital invested is pinched down to a level sneered at by any other American businessman. Nonetheless, it is agriculture that might give us some leverage in world affairs. Let me turn again, for a moment, to some history:

Norman Borlaug, Nobelist and driving force behind the development of short-stemmed fertilizer-responsive wheat, one of the major components of the green revolution of recent decades, said recently that in 1930 the world had an agricultural system that could feed only two billion people. Today we have an agricultural system that can feed five billion people, perhaps a bit better than people were fed in 1930. The recent increase in food production is, of course, as impressive as the increase in population that is inescapably dependent on it.

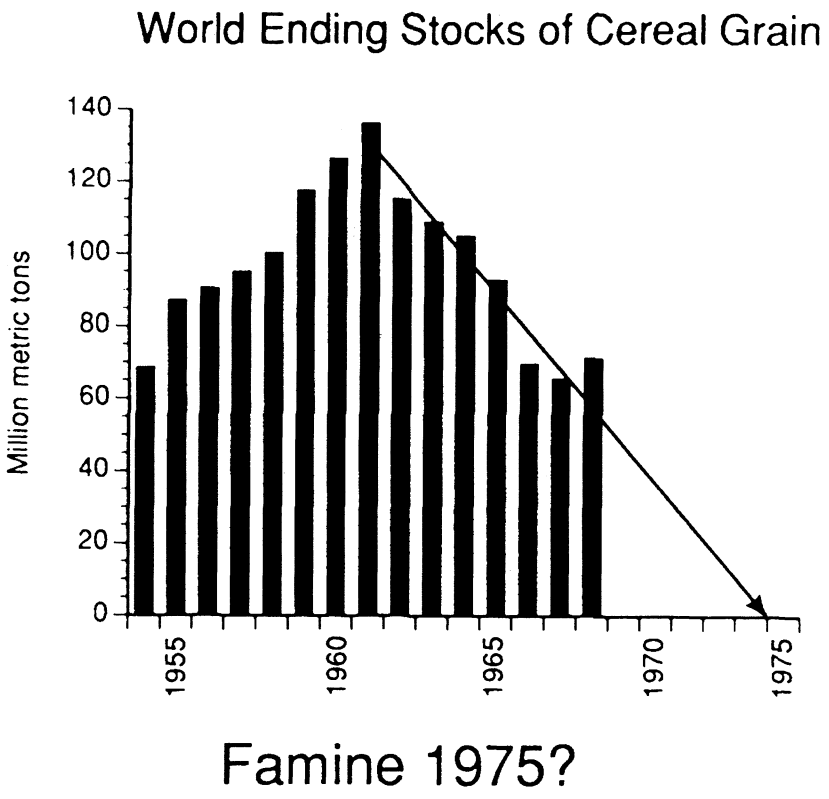
Ignoring the troubled depression and war years, the American record for the last twenty-five years, 1960 to 1985, for wheat, corn and soybeans, on a caloric basis, was a 2.3-fold increase. But the world, for wheat, corn and rice, did almost as well, 2.1-fold over the same interval. Over the same time interval, the world's population grew by 60% while the American population increase was only 30%. Fertilizer use in the United States increased rapidly from 1950 to 1985: of nitrogen, 9-fold; of phosphorous, 2-fold; of potash, 4-fold. For the world as a whole, it was even greater. Response to additional fertilizer must necessarily diminish as use increases; somewhere it approaches saturation. How close are we now?

Despite these increases in fertilizer use, in the late 1960s, annual world carryover of cereal grain stocks was dropping steadily (*Figure 8*). Steadily enough, in fact, to persuade the Paddock brothers (1975, p. 141) to predict famine in 1975 and to give that title, *Famine 1975!*, to a book. But it has not yet occurred and, commonly, we give credit to the introduction of short-stemmed fertilizer-responsive wheat and rice at the critical moment.

Coincidently though, President Nixon made a deal to sell grain to Russia that, directly or indirectly, led to a great surge in prices received by American farmers, to a four-fold increase in cornbelt cropland prices within a decade, and to a considerable increase in production quite separate from genetic improvement. For several years, as noted above, the United States provided the major share of grains in international trade.

Now, in 1990, annual world carryover is again diminishing (Figure 9). Lester Brown (1989, pp. 41-58) of the Worldwatch Institute, foresees disas-

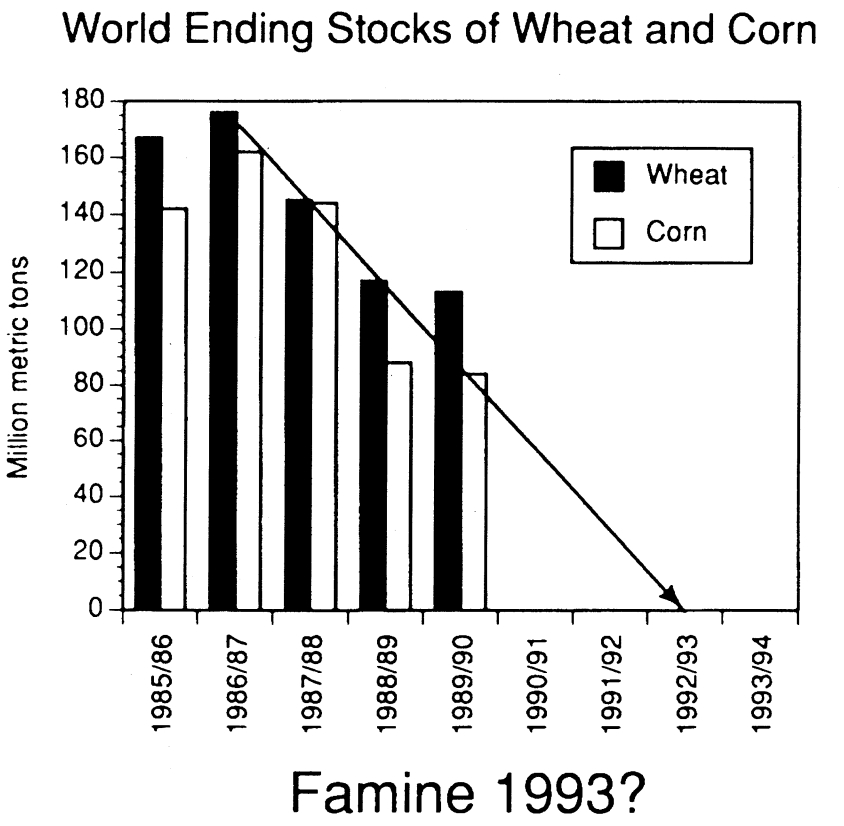
FIGURE 8. World Cereal Grain Annual Carryover, 1954 to 1968



ter, but the market does not; grain and soybean prices remain sluggish. Will we have famine in 1993? I do not know, of course; the data are less impressive. But, I am pretty sure we will not get out of many such episodes as easily as we did in the 1970s.

If food supplies do become short, say, in 1993, we can expect another surge in crop prices, in cropland prices, a lesser increase in food production, a proportionally greater increase in consumer food prices. The United States might redress some of its balance of payments deficits by a surge in food exports and we might live a bit less well at the same time by spending a larger share of our consumer dollar on food. But it will not be in the least bit simple because, of course, the worst food shortages will be in places least able to pay for imported food.

FIGURE 9. World Wheat and Corn Annual Carryover, 1986 to 1990



THE PREDICAMENT

We live in a world of accelerating change, in an evolving system of ever increasing complexity. Even though, on an historical scale of time, population growth must end soon, no one expects that to signal any slow-down in change. Our educational system has, probably inevitably, quite failed to keep pace with the burden of demands upon it. How, even, are our teachers doing? Is this system destined to became increasingly complex until none of its participants can comprehend its nature, its properties, its destination? Is it destined to grow in complexity until our role in guiding it is reduced to the same level as that of our fellow travellers in this immense journey, the birds, the animals, the fishes?

Worse, our intellectual community is either utterly ignorant of these issues, or bored, or adamantly divided. Some see a vision of infinite opportunity: "We shall make copper from iron." Others see a world of constraints: physical, biological, political, economic, ethical, inertial, of varying rigidity. What should we conclude when the best of the minds that have concerned themselves with such matters are utterly unable to come to agreement? Is it that the problem is really far more difficult than it seems? Or have we vastly overrated the reasoning powers of the human mind? Or are we plagued with subversion, intellectual dogma, hypocrisy? Or, is it simply a hidden difference in purpose: that some of us believe our society exists to serve its economy and others that the economy exists to serve the society?

Who is for growth, who against? Who is for growth: the young businessman who wishes more customers; the young lawyer or physician who seeks more clients; the junior executive who hopes for more places at the top; the construction industry, from tree-cutter to housebuilder to factory-builder to builders of all supporting facilities and all of their labor forces; and, yes, including bridge-builders. Also, the farmer who hopes for larger demand and better prices; the Office of Management and Budget which hopes this year's growth will swallow last year's deficit. And all Congressmen who know they dare not vote for a balanced budget but must hope for a surplus some day, a surplus stemming from growth.

These are the same Congressmen who must run for election every two years. How can they possibly worry about what will not happen for ten years, or a hundred? It is the same all the way down in government as in business: there is no way out except from growth.

Who else is for growth? The demographers, present company excepted, who see their careers waning with diminishing numbers; the economists, ditto, who see no viable future for a market economy without growth.

Who is for ending growth? A little band of diehards that have been fighting . . . for how long? Since Robert Malthus, and before. But, also, and this is novel: the American families, hard pressed to secure the future promised them by their Congressmen, their teachers, their economists; the families where both husband and wife must hold jobs and where child numbers drop sharply. Unwittingly, perhaps, they do most to end population growth, while voting for economic growth to the hilt.

Which is the better fate: to be remembered with honor by the grandchildren we choose not to have; or to be reviled by those we do have? And what difference is it, anyway, after we are a century dead?

Still, I am going to argue that somewhere an element of gratitude for

any restraint we may show does exist, expressed or not, within the rest of the world's biota. Perhaps I must simply say it to myself: I feel better about this world each time humanity gives any hint of concern for our fellow travellers. Perhaps, if we fail at our task, if C. G. Darwin is right, ultimately, the world will be rid of this plague of introspective humanity and can return to an unending evolution of greater and greater complexity of form and function, but not of thought.

And yet: here we are on Earth Day, twenty years later, celebrating—what? Five billion instead of four billion? But the great conservation organizations I knew when they numbered members by the few thousand, now number them by the hundreds of thousands, and their overseas affiliates not by the fingers of one hand but by the hundreds. Will they twenty years ahead count their numbers by the tens of millions? Does it really matter who wins the intellectual battle if all the world joins the Sierra Club?

And yet: the organizations themselves, where do they stand on population? Mostly, they are inattentive, apathetic. Is it too complex? Forty years ago, it seemed so simple.

Perhaps, you will forgive me if I close by falling back on the simplest of logic: William James, nineteenth century American psychologist and philosopher, brother of Henry James, once lectured to an audience on new knowledge about the solar system. Afterward, a member of the audience came forward to say, "That's a pretty picture you make of the solar system, Dr. James, but really you should know the Earth is not a sphere circling the sun. Actually it is just a crust of earth resting on the back of a giant turtle."

James, thinking to handle this by forcing a logical dilemma, asked, "But, tell me, what does this turtle rest on?"

"Oh, it rests on the back of a much larger turtle."

"And that turtle?"

"It's no use, Dr. James, it's turtles all the way down!"

And so, if you should ask me what underlies any natural resources problem, I shall answer that at root all resources problems are population problems. And if you push me for more detail, for more clarity, for proof even, all I can say is that it's population all the way down!

REFERENCES

Ackerman, E. A., technical revision by Luten, D. B. (1949). *Japanese Natural Resources*. Tokyo: General Headquarters, Supreme Commander for the Allied Powers.

Bartlett, J. (1955). *Familiar Quotations* (13th ed.). Boston: Little Brown.

Bennett, M. K. (1954). *The World's Food*. New York: Harper and Brothers.

Brown, L. R. (1989). Reexamining the World Food Prospect. In L. R. Brown et al. (eds.). *State of the World 1989*. (pp. 41-58). New York: W. W. Norton.

Darwin, C. G. (1952). *The Next Million Years*. London: Rupert Hart-Davis.

Luten, D. (1986). What American Grows. In T. Vale (Ed.). *Progress Against Growth*. New York: Guilford Press.

Malthus, T. R. (1960). A Summary View of Population. (First published in 1830.) In F. Notestein (Ed.). *On Population: Three Essays* (pp. 13-59). New York: Mentor Books.

Paddock, W. & Paddock, P. (1967). *Famine 1975!* Boston: Little, Brown.

Pearl, Raymond (1925). *The Biology of Population Growth*. New York: Knopf.

Population Reference Bureau. 1990 World Population Data Sheet; 1973 idem. Washington, DC.

Thompson, Warren S. (1949). Personal communication, Tokyo.

United Nations (variously 1948-1972). *Statistical Yearbook* (variously) *1948* (to) *1972*. New York: United Nations Publications.

United States Bureau of the Census (variously 1948-1989). *Statistical Abstract of the United States* (variously) *1948* (to) *1989*. (variously 68th to 109th ed.). Washington, DC: U.S. Government Printing Office.

United States Department of Agriculture (variously 1963-1988). *Agricultural Statistics* (variously) *1963* (to) *1988*. Washington, DC: U.S. Government Printing Office.

United States Department of Commerce (1975). *Historical Statistics of the United States: Colonial Times to 1970*. Parts 1 and 2. Washington, DC: U.S. Government Printing Office.