A "Law of Growth": The Logistic Curve and Population Control since World War II

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International Conference "Technological and Aesthetic (Trans)Formations of Society", Darmstadt Technical University, October 12-14, 2005. Session "Normalizing by Images – Imaging Normalization"

Abstract

"Population" has become a crucial factor in national and global politics. The assessments of "demographic transitions", however, considerably diverge. Whereas the North has come to discuss population dynamics in demographic terms of ageing and decline, international efforts focus on the problems of increasing world population growth, carrying forward predictions of a "population explosion" and demands for a rigorous "population control" raised in the decades following World War II. To reflect on the conflicting terms of the present debate, it is rewarding to study the revival of the Malthusian population-resources-environment predicament in the "environmental decade" of the 1960s and 1970s. Paul Ehrlich's image of the "population bomb" and Lester Brown's "lily pond" were examples of the perception of uncontrolled population growth in this period. "Overpopulation" related human numbers to a model from population ecology which described the self-limiting growth of self-contained biological populations. This natural "law of population growth" condensed population development in a simple mathematical expression and in a visual representation: the S-curve or "logistic growth curve" displayed a human population facing imminent demographic doom, or "ecocide".

The paper argues that in the mathematical structure of the growth model, the issue of global population control was represented as an accounting problem of *storage*. The law of growth naturalized and rationalized the perception of limited global cargo space, seeking mathematical solutions to political quandaries involving global disparities of wealth and power. To examine the performative strength of the logistic curve the paper discusses the world models of the Club of Rome's study *Limits to Growth* in 1972, where the "standard run" denoted the unrestrained world development which would allegedly lead to "collapse". Against this "standard" environmentalists introduced their propositions for population control. Their framing of the earth's limited "carrying capacity", however, stabilized the mathematical construction of population growth. The paper discusses concepts like Garrett Hardin's "lifeboat ethics", the Paddocks brothers' system of "triage" and Kenneth Boulding's marketable "child certificates" as examples of regulatory suggestions which contributed to normalizing the growth law and its inherent threats, informing population discourse until today.

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1 This paper draws on my research for my current work on the discourse on "Spaceship Earth" in the Environmental Age. It is part of a larger project on the Discourse of Sustainable Development (NEDS), funded by the German Ministry of Education and Research (# 624-40007-07 NGS 11). Parts of my work have been published previously, see Höhler, Sabine, "'Raumschiff Erde': Lebensraumphantasien im Umweltzeitalter", in: *Welt-Räume. Geschichte, Geographie und Globalisierung seit 1900*, eds. Iris Schröder and Sabine Höhler, Frankfurt a. M., Campus 2005, pp. 258-281; "'Carrying Capacity' – the Moral Economy of the 'Coming Spaceship Earth'", paper prepared for the 4S & EASST Meeting, Paris, August 25-28, 2004 (http://www.neds-projekt.de/Download/download.html).

Preface: 20th-Century Rise and Decline – A "Clever Montage"

The two-minute movie entrance sequence outlines an impressive visual and aural history of the 20th century. It starts with long shots showing the optimistic times of rising industrialization in the beginning of the century, symbolized by the first fragile cars and primitive airplanes. This rather moderate heading into modernity is accompanied by a slow waltz. As we observe the century proceeding, the pictures are replaced by modern industrial settings and the output of mass production; we see smoke stacks and arrays of cars coming from the assembly line. As the music picks up speed and changes to a quick beat, the succession of pictures accelerates as well; the screen splits as images double and then multiply, changing with rising frequency. Also, what we see changes: more and ever more people are shown in frantic succession. The images come in colour now, denoting the post-World-War-II lifestyle of affluence in the North-West. We see urban crowds in the 1950s and 1960s. From within this frenetic rhythm of pictures and music, we begin to recognize the effects of rising industrial pollution pointed out to us by dying trees, industrial waste, smog, and by people wearing masks. Then the music slows down to the beat from the beginning, the images slow down, and we know that we have again moved on in time: Now we watch waste areas, destroyed forests, barren industrial sites. Finally, the sequence "comes to a grinding halt" with the sight of the thickly polluted cityscape of New York City. The year is 2022. The population is 40 Million.

"Population Explosion" and "Ecocide": Growth in the "Environmental Age"

Thus closes the entrance sequence to the movie "Soylent Green", a troubling dystopia produced in the USA in 1972 and released in 1973.[2] What is commonly classified as "Science Fiction" was, according to film director Richard Fleischer, neither about science, nor was it pure fiction or fantasy. Instead, "Soylent Green" linked two pressing concerns of its time: "overpopulation" and "overpollution". Fleischer's "cleverly devised" montage represents this link, displaying exponential growth and stagnation, or "population explosion" and "ecocide", to use two widespread terms of the time. In its visual and acoustic structure the sequence

2 "Soylent Green" is *the* science-fiction movie about earthly limits and limitation. The screenplay is based on a novel by Harry Harrison called *Make Room! Make Room!* (Garden City, New York, Doubleday 1966). The book's argument about extreme population growth, environmental degradation, scarcity, mass uprising, and mass mortality, was quite common for its times. Thus, the book's title signifies both the overcrowded world and the merciless police practices of riot control. The 2003 film DVD provides informative supplementary material: an extra audio track from 2003 with the retrospective commentaries by director Richard Fleischer and by the leading actress Leigh Taylor Young who played the figure of Shirl, and a short documentary with the title "A Look into the World of Soylent Green". The quotes given in the paper are Fleischer's comments.

matches the "Biological Growth Curve" to which population ecologists referred to describe the development of a population over time. The S-shaped curve related population size and time according to a "natural law" of population growth, proposed in the mid-19th century and reestablished in the 1920s. The "constraining factor" in the growth pattern, biologists explained, consisted in the confinement of most populations to a strictly limited area. Framed by such limitations, population development was held to be characterized by exponential growth up to a "point of inflection" when environmental feedback would cut in, and subsequently, progressive deceleration and decline would occur.

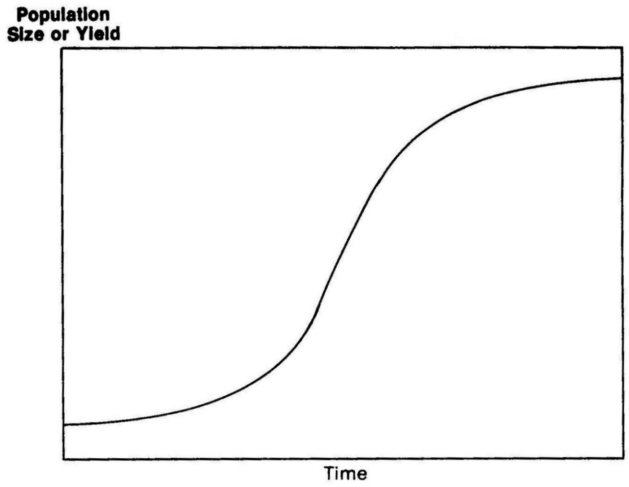

Figure 3-1. The S-Shaped Biological Growth Curve

This *mathematical model* was derived from observing the growth of self-contained biological populations bred within sealed glass jars. Nevertheless, it was held valid to describe human population development as well. The first half of the curve was familiar since the early 1800s, when the Reverend Thomas Robert Malthus published his thoughts on the "principle of population".[3] He had proposed straightforward numerical rules to forecast the disparate development of population and food supply. According to Malthus, the number of people increased geometrically, while food supply tended to increase arithmetically. In the so-called "Environmental Age"[4], in the mid-1960s and 1970s, scientists

3 Malthus, Thomas, *An Essay on the Principle of Population, as it Affects the Future Improvement of Society with Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers*, London 1798.

4 "Environmental Era"; also "Environmental Decade"; see for instance Andrews, Richard N. L., *Managing the Environment, Managing Ourselves. A History of American Environmental Policy*, New Haven/London, Yale University Press 1999, p. 228. Donald Worster dated the beginning of the "Age of Ecology" back to the ignition of the first atomic bomb in Alamogordo, New Mexico, in July 1945; Worster, Donald, *Nature's Economy. A History of Ecological Ideas* ("Studies in Environment and History"), Cambridge/New York, Cambridge University Press 1977. Nevertheless, the 1960s are considered the "time of awakening" to identify environmental problems and to form an environmental movement (see for the USA: Hays, Samuel P., *Conservation and The Gospel of Efficiency. The Progressive Conservation Movement, 1890-1920*, Cambridge, Mass., Harvard University Press 1959). The year 1970 is regarded as the beginning of the "environmental era" in the western world. Concerning the dominant issues of the time see Hays, Samuel P., *A History of Environmental Politics since 1945*, Pittsburgh, Pa., University of Pittsburgh Press 2000; Hays, Samuel P., *Explorations in Environmental History: Essays*, Pittsburgh, Pa., University of Pittsburgh Press 1998; Hays, Samuel P., *Beauty, Health and Permanence. Environmental Politics in the United States, 1955-1985*, Cambridge, Mass., Cambridge University Press 1987.

again addressed the Malthusian predicament and anxiously asked the long-standing question: "How Many People Can the World Support?"[5]

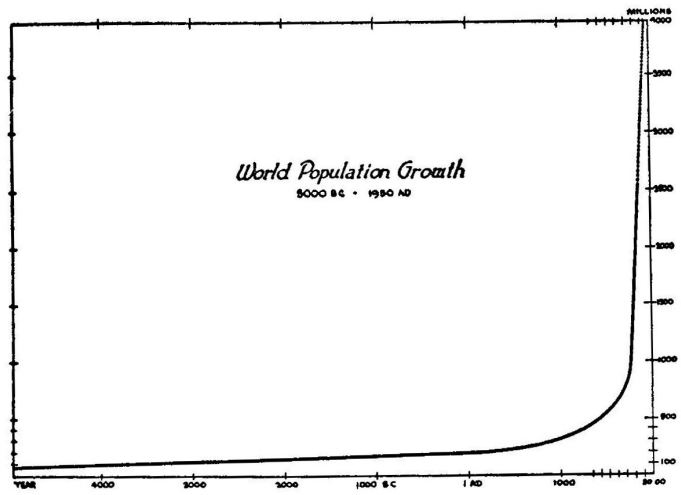

FIGURE 3
WORLD POPULATION GROWTH (5000 B.C. to 1950 A.D.)

The *empirical* world population growth curve presented in that time explains why the contemporaries deemed their situation so unique in history: much more disturbing than the population having reached roughly three billion people was the "nature" of growth being exponential, that is, the population having doubled within less than a century and increasing at a rate that led to anticipate another doubling within merely one generation. "Unprecedented Growth" came to be a much used word in the many texts on the "population problem": (Western) society considered itself positioned at the *end* of an exponential process of growth where the limits would appear very suddenly. Lester Brown, president of the World Watch Institute, used the image of the "global lily pond" to convey the pressing threat: If a lily pond of single leafs, he asked, whose number doubles each day, is completely full on the thirtieth day, when is it half full? The answer was: on the twenty-ninth day.[6] The global lily pond, so his warning, may already be half full. Similarly alarming pictures were spread by human ecologists, like Paul Ehrlich, who in his book *The Population Bomb* in 1968 proclaimed: "Clearly, a long history of exponential growth does not imply a long future."[7]

5 Fremlin, J. H., "How Many People Can the World Support?" *New Scientist* No. 415, 29 October 1964, pp. 285-287. On the history of revisiting the Malthusian predicament in the "Environmental Age" see Linnér, Björn-Ola, *The Return of Malthus: Environmentalism and Post-war Population-Resource Crises*, Leverburgh, Isle of Harris, White Horse Press 2003; Neurath, Paul, *From Malthus to the Club of Rome and Back: Problems of Limits to Growth, Population Control, and Migrations*, Armonk, N.Y., Sharpe 1994.

6 Brown, Lester R., *The Twenty-Ninth Day. Accommodating Human Needs and Numbers to the Earth's Resources* (A Worldwatch Institute Book), New York, W. W. Norton 1978, introduction p. 1 and back cover.

7 Ehrlich, Paul R., *The Population Bomb*, New York, Ballantine ^{4}1969 [1968], Prologue, p. 11.

"Population" and "Overpopulation" – Statistical Concepts and their Consequences

"In just two or three years", Ehrlich went on, "it became possible to question growth, to suggest that DNA was greater than GNP"[8]. Some scientists proposed that, with the present rate of population growth, "in 600 years the entire earth would provide only one square yard of land per person".[9] These statistical accounts of a human congestion unable to feed provided suggestive images of the world growing toward asymptotic saturation. The movie sequence shown represented precisely this entropic regression that the "natural law" of population growth and its S-shaped growth curve forecasted.

In this paper, I argue that the S-shaped growth curve not simply depicted but created a "world population" facing imminent doom. Only within the statistical-mathematical frame, the concept of "world population" gained the epistemic status of a natural entity, of a life form with a natural course of development and a natural life cycle. Expressed as a relatively simple numerical equation and visualized by a highly evocative graph, the "law of population growth" naturalized a particular mathematical model of population development. The statistical-numerical rationalization went along with deep social and political implications: The law of growth and its parameters produced and organized the world's "population problem" as an accounting problem of the "classification" and "storage" of "human elements", to quote a thought by Michel Foucault on 20th-century biopolitics.[10] Accordingly, I propose to discuss how the growth curve, by supplying visual evidence of the self-limiting growth of a self-contained world population, enabled setting standards as to "normal" population development, and to its quantitative deviation: "overpopulation".

The Life of P in Words, Numbers, and Images

"Let P = population". With this equation Barbara Duden reminds us that "population" is not a natural given but an aggregate of statistical data "used to generate the semblance of a

8 Ibid., Foreword, p. 14.

9 Sax, Karl, *Standing Room Only. The World's Exploding Population*, Boston, Beacon Press 1960 [orig. 1955 under the title *Standing Room Only. The Challenge of Overpopulation*], preface, p. xii.

10 The notions of "classification" and "storage" I borrowed from Foucault's thoughts on the 20th century: "This problem of the human site or living space is not simply that of knowing whether there will be enough space for men in the world […], but also that of knowing what relations of propinquity, what type of storage, circulation, marking, and classification of human elements should be adopted in a given situation in order to achieve a given end." Foucault, Michel, "Of Other Spaces", *Diacritics*, spring 1986, pp. 22-27 (orig. "Des Espaces Autres", 1967), p. 23.

referent", which is then addressed as the real object of development policy.[11] Within this statistical frame of reasoning, Duden claims, "'P' acquires a life of its own". With the onset of "social physics" in the early 19th century, populations were turned into natural subjects which "grow, consume, pollute, need, demand, are entitled". At the same time, they became natural "objects that can be acted upon, controlled, developed, [and] limited."[12]

"In this transition, a new language came into being, created to observe people in quantitative contexts."[13] Formal mathematics, statistics, and, correspondingly, an emerging vocabulary of demography were constitutive of the new human collectives acquiring shape. Representations of populations as self contained entities in terms like "population dynamics", or, in the later 20th century, in terms like "population explosion" and "population screening", are language acts, which trim human beings to fit a single common denominator for the sake of accountability: these terms accomplish homogeneity, comparability, and, eventually, commutability of elements which were never same or even similar.[14]

Next to words, images like tables and graphs are devices by which narratives "are transformed into readily visualized representations of aggregate numbers"[15]. A table with two columns and

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11 Duden, Barbara, "Population", in: Sachs, Wolfgang (Hrsg.), *The Development Dictionary. A Guide to Knowledge as Power*, London, Zed Books 1992, pp. 146-157, quotes p. 146, p. 149.

12 Ibid., p. 146. On "social physics" and the rise of population statistics in the 19th century see Desrosières, Alain, *The Politics of Large Numbers. A History of Statistical Reasoning*, Cambridge, Mass., Harvard University Press 1998; Porter, Theodore M., *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life*, Princeton, N. J., Princeton University Press 1995; Porter, Theodore M., *The Rise of Statistical Thinking, 1820-1900*, Princeton, N. J., Princeton University Press 1986; Hacking, Ian, *The Taming of Chance*, Cambridge, Cambridge University Press 2004 (orig. 1990); Wise, M. Norton (Ed.), *The Values of Precision*, Princeton, N. J., Princeton University Press 1995.

13 Duden, "Population", p. 148.

14 Link, Jürgen, „Aspekte der Normalisierung von Subjekten", in: Gerhard, Ute, Link, Jürgen, Schulte-Holtey, Ernst (Eds.), *Infografiken, Medien, Normalisierung. Zur Kartographie politisch-sozialer Landschaften*, Heidelberg, Synchron 2001, pp. 77-92, on homogeneity though statistical representation p. 83. On „normalization" Link, Jürgen, *Versuch über den Normalismus. Wie Normalität produziert wird*, Opladen/Wiesbaden, Westdeutscher Verlag 1999 (2. ed.); Sohn, Werner, Mehrtens, Herbert (Eds.), *Normalität und Abweichung. Studien zur Geschichte und Theorie der Normalisierungsgesellschaft*, Opladen/Wiesbaden, Westdeutscher Verlag 1999. On quantification and accounting practices Porter, Theodore M., "Quantification and the Accounting Ideal in Science", in: Biagioli, Mario (Ed.), *The Science Studies Reader*, New York/London, Routledge 1999, pp. 394-406; Porter, Theodore M., "The Culture of Quantification and the History of Public Reason", *Journal of the History of Economic Thought* 26 (2004) 2, pp. 165-177; *Facts and Figures. Economic Representations and Practices*, ed. Herbert Kalthoff, Richard Rottenburg, Hans-Jürgen Wagener (*Ökonomie und Gesellschaft*, 16), Marburg, Metropolis 2000; Klein, Judy L., Morgan, Mary S. (Eds.), *The Age of Economic Measurement*. Annual Supplement to Volume 33 *History of Political Economy*, Durham/London, Duke University Press 2001.

15 Duden, "Population", p. 149. On the power of (scientific) images in the perception of reality see Gugerli, David, Orland, Barbara (Eds.), *Ganz normale Bilder. Historische Beiträge zur visuellen Herstellung von Selbstverständlichkeit* („Interferenzen", Vol. 2), Zürich, Chronos 2002; Nikolow, Sybilla, Bluma, Lars, „Bilder zwischen Öffentlichkeit und wissenschaftlicher Praxis. Neue Perspektiven für die Geschichte der Medizin, Naturwissenschaft und Technik", *NTM* 10 (2002), pp. 201-208; Gerhard, Ute, Link, Jürgen, Schulte-Holtey, Ernst (Eds.), *Infografiken, Medien, Normalisierung. Zur Kartographie politisch-sozialer Landschaften*, Heidelberg, Synchron 2001; Lynch, Michael, Woolgar, Steve (Eds.), *Representation in Scientific Practice*, Cambridge, Mass./London, The MIT Press 1990.

15 lines effectively cuts down the characters needed to illustrate Malthusian geometric or exponential population growth.

Years	Millions of people
0	1
50	2
100	4
150	8
200	16
250	32
300	64
350	128
400	256
450	512
500	1,024
550	2,048
600	4,096
650	8,192
700	16,384

Figure 1-1 Population growth during 700 years, with a doubling time of 50 years.

Then again, the table's sequence is plain compared to the chart "plotted to scale". The resulting growth curve enables individuals to pinpoint the current situation of the collective, its past, and its imminent future at one glance. Moreover, whereas the table simply tabulates numbers, the curve plays to its strength in the choice of vertical scales, making "growth appear so steep and sudden".[16]

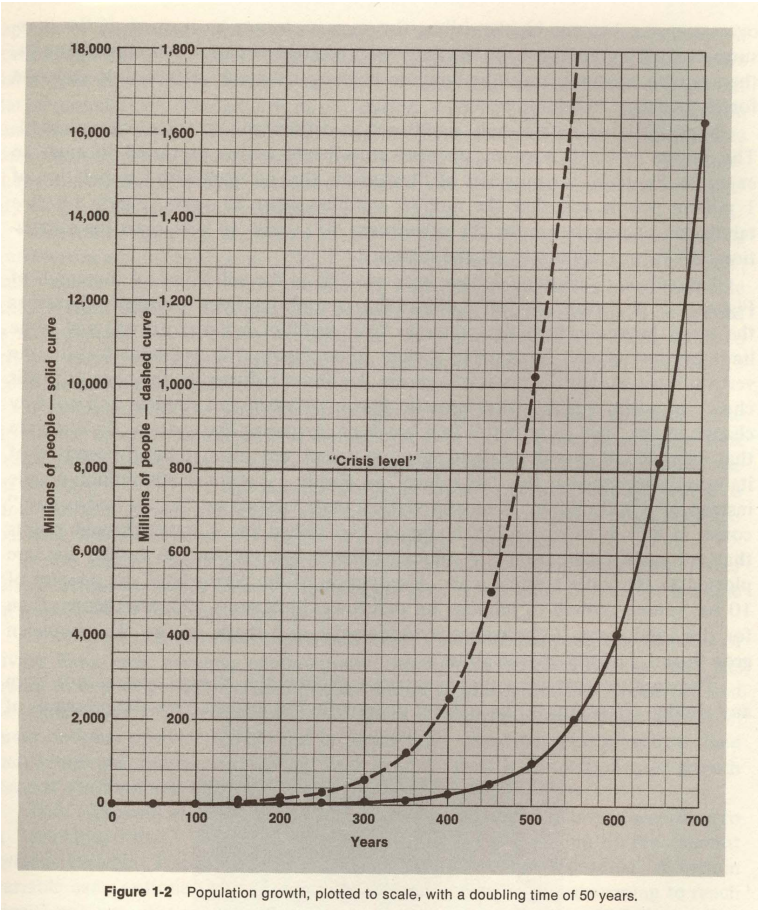

Figure 1-2 Population growth, plotted to scale, with a doubling time of 50 years.

Both table and graph are taken from Jay Forrester's book on *World Dynamics* in 1971. Forrester provided the "World Model", the computer program to model world development, for *The Limits to Growth*, the Club of Rome's Report on the "Predicament of Mankind" in 1972, which put new stress, and literally much pressure, on *world* population as a whole.[17] "Population", as Duden noted, "had become a variable analogous to capital, labor, technology, or infrastructure in a 'world system'."[18]

16 Forrester, Jay W., *World Dynamics*, Cambridge, Mass., Wright-Allen Press 1971, p. 3.

17 Meadows, Donella H., Meadows, Dennis L., Randers, Jørgen, Behrens, William W. III, *The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind*, New York, Universe Books 1972.

18 Duden, "Population", pp 153-154.

Pearl's "Law of Population Growth"

Since the beginning of the 19th century, formalized mathematical-statistical means of quantification had sought to impose constant patterns on seemingly fleeting and ever-changing organic life. Not only political economists interested in "social physics", like Malthus and his contemporaries, but also natural philosophers like Charles Darwin were fascinated by "the quantity of life" and the ways that quantity was held in check. Population studies created a hinge between evolutionary biology and ecology. In the 1920s, studies of how (Darwinian) selective pressures and (Malthusian) checks acted on population numbers, mainly in the field of entomology, opened a field that within a decade was recognized as "population ecology". In her book *Modeling Nature*, published first in 1985, Sharon Kingsland has recounted the early history of population ecology and discussed some of the strengths and the weaknesses of mathematics and statistics to reduce natural complexity, resulting in regularity and comparability on the one hand, and in establishing reduced mathematical truths about nature on the other. "The questions involved numbers, and the answers seemed to lie in the direction of mathematics", Kingsland notes. "Before too long, the mathematical answers began to appear."[19]

Johns Hopkins biologist Raymond Pearl was a proponent of this statistical-mathematical view on nature. During the 1920s, when emphasis was put on laboratory experiments on population sequences and cycles and on single-species aggregations or groups, Pearl combined a mathematical point of view with an experimental style. With his studies on *drosophila* (fruit flies), Pearl built a program in comparative demography. Biostatistics became his method of a new biology, not of individuals, but of groups. In a systematic attempt to apply demographic techniques to animal populations, he borrowed from social statistics the established tools of life tables, death rates, and life expectancies. When the predicament of population and food supply came up again in the aftermath of the First World War, Pearl, in conjunction with his laboratory studies, started to engage in the problem of human population growth. Together with the mathematician Lowell J. Reed he began analyzing rates of population growth. The degree of mathematization he was seeking was allowed for through the information available in the accumulated body of statistics, on fertility, growth, disease, or mortality.

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19 Kingsland, Sharon E., *Modeling Nature. Episodes in the History of Population Ecology*, Chicago/London, The University of Chicago Press 1995 [1985], Chapter 3 "The Quantity of Life", pp. 50 ff., quote p. 56. For the story on Pearl see especially pp. 56-63. To outline the history of Pearl's population studies and of his growth curve, I drew on information given in the paragraph on "The Logistic Hypothesis", p. 64 ff.; furthermore, I studied Pearl's crucial book on the topic, Pearl, Raymond, *The Biology of Population Growth*, New York, Alfred A. Knopf 1930 [revised edition, orig. 1925].

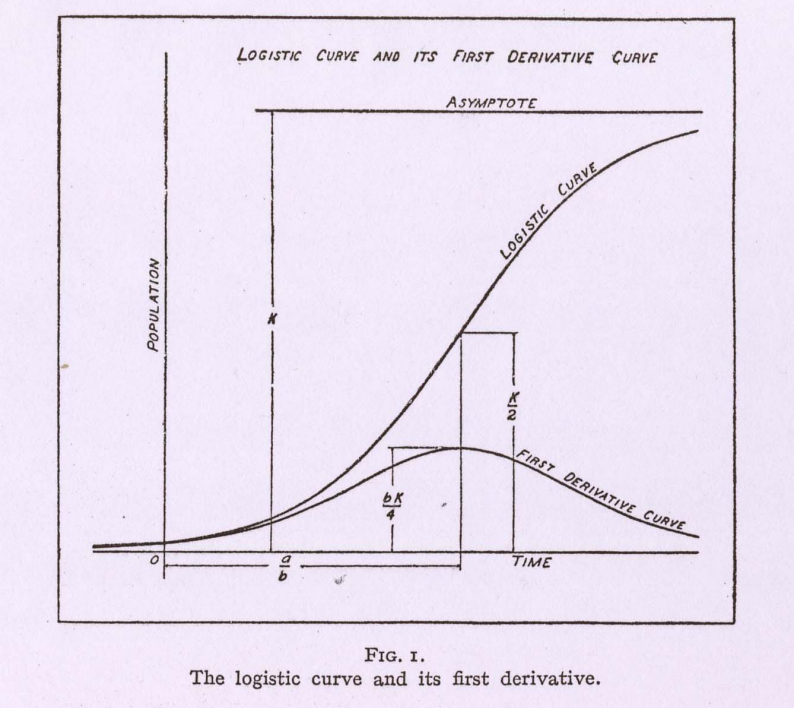


FIG. 1.
The logistic curve and its first derivative.

Pearl's "search for quantitative measures and correlations under different experimental conditions" aimed at establishing a *law* of population growth, expressed as a mathematical equation which would conform to experimental observations as well as to assumptions about how populations behaved, to indicate future trends reasonably accurately.[20] Pearl and Reed presented their equation in 1920. They called the corresponding graph the "logistic curve", recalling the work of the Belgian Pierre-Francois Verhulst, who more than eighty years earlier had described population growth in a similar way and in 1845 had called his curve of growth over time "logistique".[21] Pearl and Reed adopted the term "logistic" for their smooth, S-shaped curve

20 Kingsland, *Modeling Nature*, p. 64, quote p. 61. According to Kingsland, Pearl became a convert to the statistical view of nature that Karl Pearson advocated. He believed in unbiased, consistent, and comprehensive scientific method to formulate scientific "laws". Articulating and establishing sense from the orderly classification of facts, and from relationships and sequences between isolated phenomena, science would represent the fundamental "laws of nature"; ibid., p. 58. On the term and notion of "law" (theory, generalization, description, explanation) see ibid., p. 68.

21 Pearl, *The Biology of Population Growth*, p. 4, refers to Verhulst's using of the same curve which he called the "logistic curve", as early as 1838. In his *Treatise on Man* of 1835, Verhulst's mentor Adolphe Quételet, with reference to Malthus's observations, had proposed two fundamental principles in the analysis of development of population: "*Population tends to increase in a geometrical ratio. The resistance, or sum of the obstacles to its development, is, all things being equal, as the square of the rapidity with which it tends to increase.*" Quételet, Adolphe, *A Treatise on Man and the Development of his Faculties*. Facsimile Reproduction of the English Translation of 1842, New York, Burt Franklin 1968 [orig. *Sur L'Homme, et le Développement des ses Facultés*, Paris 1835], p. 49, his emphasis. According to Kingsland, Verhulst was unable to determine the exact nature of the function that described the obstacles to growth. He suggested the obstacles were in *linear* proportion to the size of the "superabundant" population (the number in excess of the "normal" population, the one in accord to the resources available); Kingsland, *Modeling Nature*, p. 65. In nineteenth-century French, the term "logistique" referred to the art of calculation as opposed to theoretical arithmetic. Kingsland suggests that the term conveyed "the idea of a calculating device, from which one could calculate the saturation level of a population and the time when it would reach that level"; ibid. Another precursor, whose curve Pearl and Reed used, was T. Brailsford Robertson. Using Quételet's data, the physiologist around 1908 applied the sigmoidal curve to growth problems. In analogy to chemistry, he labeled his curve "autocatalytic" or self-accelerating. He postulated that growth itself was an autocatalytic phenomenon. Although they had criticized this curve earlier, Pearl and Reed used it in 1920; ibid., p. 66.

towards a stable upper limit. In Kingsland's words, the curve eventually "contributed to population ecology one of its simplest mathematical models".[22]

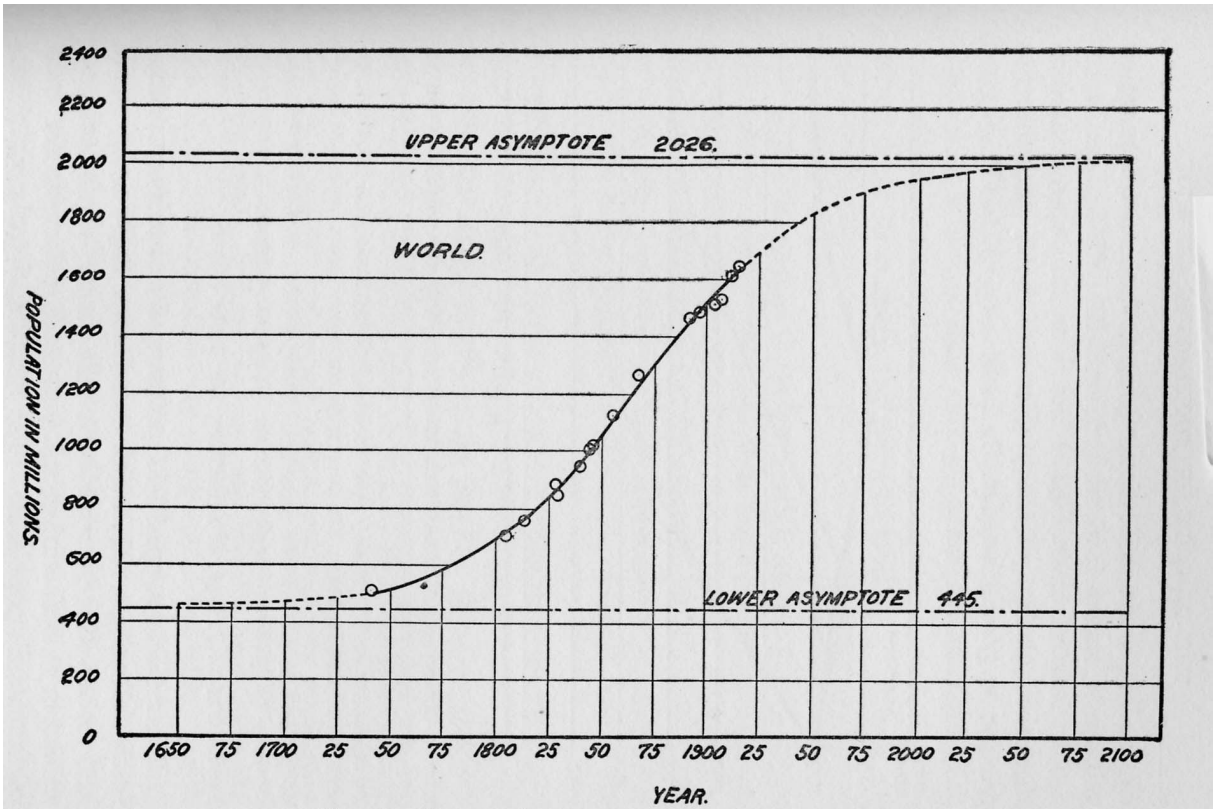


FIG. 30. The growth of the population of the world.

In Pearl's words, the curve demonstrated that "plainly all growth, including that of population, is fundamentally a biological matter".[23] In his times, Pearl's results led to a controversy over the basic assumptions that went with the law and the curve; among them, the implication of symmetry, with the point of inflection exactly halfway through the curve. To many contemporaries, it seemed an idealization that the forces in the first half were exactly as strong and distributed as in the second half. However, a generalization of the equation to free the curve from its restrictive symmetry would imply that the curve could be made to fit almost any data, with the consequence that it could not be considered a calculating device with prognostic value, and hardly a "law" in the strong sense. Pearl and Reed "had assumed that which had to be proved, yet they presented their curve as being empirically fitted, not

22 Ibid., p. 64.

23 Pearl, *The Biology of Population Growth*, p. 3. "In the face of the considerable evidence now at hand, which could be still further multiplied, it is irresistibly borne in upon one that all the complexities of human behaviour, social organization, economic structure, and political activity, seem to alter much less than would have been expected the results of the operation of those biological forces which basically determine the course of the growth of populations of men, as well as those of yeast cells", ibid., p. 18.

logically derived."[24] Pearl's 1925 book on *The Biology of Population Growth* demonstrates how the sparse population data of different countries were accumulated and arranged along the curve line, and then extrapolated to fit the logistic world population growth curve. To quote Kingsland again, "Pearl had come full circle: having first *assumed* logistic growth in trying to find a curve to fit his initial data, he now believed that the empirical evidence proved the truth of the logistic 'law', even though large parts of the curves were extrapolated." [25]

The "Nature of Exponential Growth" as a Tool in Environmental Reasoning

"Pearl understood that new ideas gained strength through repetition", Kingsland noticed. "The few ideas which, in the form of simple mathematical models, did enter ecology and formed the kernel of the intellectual tradition that grew into population ecology, often owed their survival to the fact that they were intensely promoted and consequently highly visible."[26] The logistic growth curve took its performative strength from its smoothness and symmetry, its highly aesthetic quality. Its perfect form suggested truth, universality, and eternity. Uwe Pörksen has called such types of images "visiotypes", stressing the typecast amalgam of text and image able to translate quantitative knowledge into (self) orientation and regulation and capable to set standards of public perception of – in the case of population – global reach. According to Pörksen, visiotypes are social tools: They establish abstract general denominators to assemble large and sometimes incoherent parts of society, and they display future movements, or trends.[27]

In the early 1970s, the disputes over Pearl's use of one single equation to describe the growth of a population had subsided, and the differences between Pearl's extrapolated "trends" and the natural „law" of growth were fading. The graphical device of the logistic growth curve had done its work, constructing the logic it described, apparently illustrating the *nature* of things. The curve provided the narrated accounts in this time

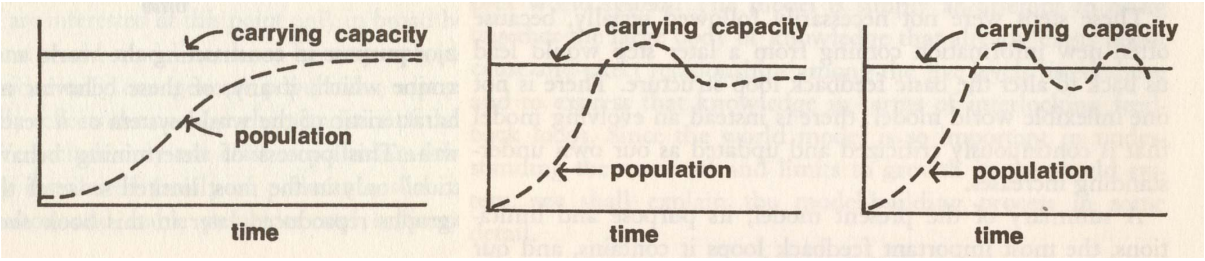
24 Kingsland, *Modeling Nature*, p. 67-69.

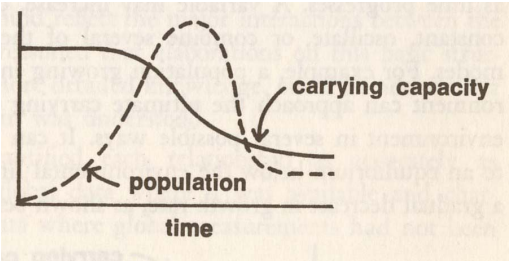
25 Ibid., p. 75.

26 Ibid., p. 75, p. 56.

27 Pörksen, Uwe, „Logos, Kurven, Visiotype", in: Gerhard/Link/Schulte-Holtey, *Infografiken, Medien, Normalisierung*, pp. 63-76; for a definition of "visiotype" see p. 67, for its characteristics p. 73, for "trends" p. 67. On problematic trend-extrapolations through graphs see also Krämer, Walter, "Verborgene Botschaften in Infografiken", in: Gerhard/Link/Schulte-Holtey, *Infografiken, Medien, Normalisierung*, pp. 55-62.

with a definite shape.[28] In the hands of human ecologists, the logistic curve became a device to convene individual subjects to an abstract large-scale "world population" with an obvious common destiny. The world population growth curve literally drew together a world community of fear in sight of utmost earthly limits.[29] Pörksen states that in visiotypes one can hear the time ticking.[30] In the population growth curve, one could literally hear the "Population Bomb" ticking.





Nevertheless, the logistic curve, covering some definite time span, seemed to represent one single cycle of growth only. From the empirical world population growth curve a variety threatening trend curves were extrapolated, giving rise to heated debates. Images of a cyclical population growth, within successive cycles, were accompanied by images of "overshooting", of growing too far and then "collapse", and images of regression and standstill. The problem was confronted in 1972 with the study *Limits to Growth* on the scale of the whole earth: The first chapter on "The Nature of Exponential Growth" reestablished the exponential part of the logistic curve and worked out different future scenarios. With basic types of survivorship curves, possible "behavior modes of the population-capital system" were displayed, that is, the tendencies of a variable like population in the system to change over time. According to the report, a population growing in a limited environment, could approach "the ultimate carrying capacity" in several possible ways: it could "adjust smoothly to an equilibrium below the environmental limit by means of a gradual decrease in growth rate" – which would be Pearl's version –, it could "overshoot the limit and then die back again in either a smooth or an oscillatory way", or it could "overshoot

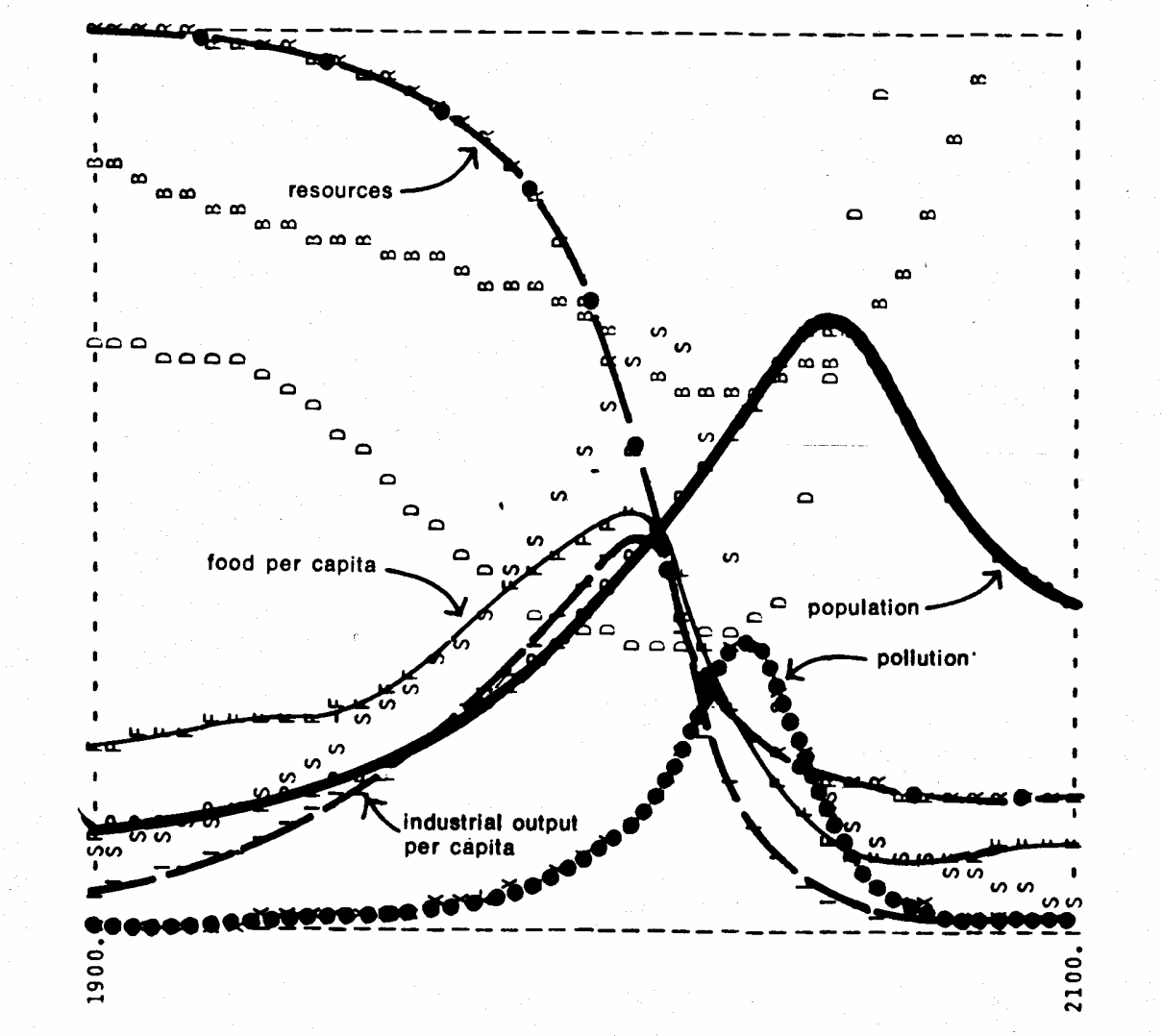
28 Pörksen, „Logos, Kurven, Visiotype", p. 74. Pörksen refers to the (empirical) exponential population growth curve, not to the modeled S-curve with its part of regression.

29 Ibid., on the power of curves to pull people into communities of fear p. 67.

30 „Es ist überraschend, wie oft die Visiotype diesen Moment der Bewegung in die Zukunft enthalten. In ihnen tickt die Zeit." Ibid., p. 73.

the limit and in the process decrease the ultimate carrying capacity by consuming some necessary nonrenewable resource".[31]

Figure 35 WORLD MODEL STANDARD RUN



The notion that a limited environment could be represented within systemic limits was exemplified in the computer program to plot the "behavior mode" of the "world system". The computer output based on unrestrained world development was called the "standard run". It assumed unchanged major physical, economic and social relations up to the year 2100. The behavior mode of the "standard run" turned out to be "that of overshoot and collapse"[32], a threatening curve scenario of rapid growth and rapid decline.[33] This "World Model" presented

31 Meadows et al. *The Limits to Growth*, p. 91 f.

32 Ibid., p. 125.

33 From the standard expectation, possible alternate developments were extrapolated by mathematical modeling of several central, coupled variables under different boundary conditions. Ibid., Chapter V: "The State of Global Equilibrium", pp. 156 ff., regarding the examination of the world in terms of systems

an alarming scenario of "denormalization".[34] At the same time, the term "standard" denotes that the curve displayed not only a probable trend, but an expectation: the performance prescribed a specific type of growth and regression, "normalizing", as Jürgen Link has argued, a "trend story" of "boom" and "crash".[35]

"Lifeboat Ethics": Suggestions for "Population Control"

Visiotypes, Pörksen pointed out, facilitate the formulation of "global equations", they allow for very simple equalizations.[36] He also reminds us that to use very simple equations on very large scale objects is practically meaningless, since the entities applied are missing any social index or size. Political and social contexts are excluded from such computations. On the other hand, these kinds of exclusion allow the arguing on such a large scale to become so powerful. To conclude, I would like to discuss some of the contemporary propositions for "population control" environmentalists introduced *against* the expected "standard run" of the world.

Speaking of the "law of population growth" moved questions of politics to the realm of the natural sciences and deflected from considering global disparities of wealth and power. Human ecology asked, "What is the *optimum number* of human beings that the earth can support?"[37] The question framed the world's "population problem" as an accounting problem of efficiently allocating human elements to a limited 'cargo space'. To take up Sharon Kingsland's reminder, the question involved numbers, and the answers came from the direction of mathematics. The economist Kenneth Boulding, for instance, considered a system of allocating birthrights to potential parents, employing market mechanisms to lower the birth rate in the U.S.A.[38] Within this "system of marketable licenses to have children", Boulding proposed, the unit might be the "decichild". Certificates could be traded, and the "accumulation of ten of these units by purchase, inheritance, or gift would permit a woman in

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analysis. Stabilized World Models I and II are presented, which display different states of equilibrium regarding the variables taken into account.

34 Schulte-Holtey, Ernst, "Über Kurvenlandschaften in Printmedien", in: Gerhard/Link/Schulte-Holtey, *Infografiken, Medien, Normalisierung*, pp. 93-114, on denormalization p. 101; Link, *Versuch über den Normalismus*, p. 200.

35 "Aufschwung" and "Absturz"; Link, „Aspekte der Normalisierung von Subjekten", p. 88, for a typology of normalistic basic curves (growth curves, regression curves, and S-curves) and normalistic narrations.

36 Pörksen, „Logos, Kurven, Visiotype", p. 74.

37 Ehrlich, *The Population Bomb*, p. 167, my emphasis. The concept of a redundant population was a central element of Malthus's theory in 1798; the question of an "optimum population" was already posed at the first World Population Conference in 1927, see Fairchild, H. P., "Optimum Population", in: Sanger, Margaret (Hrsg.), *Proceedings of the World Population Conference, held at the Salle Centrale, Geneva, August 29th to September 3rd, 1927*, London, Edward Arnold & Co. 1927, pp. 72-85.

38 Boulding, Kenneth E., *The Meaning of the Twentieth Century. The Great Transition*, New York, Harper & Row 1965 [1964], Chapter VI., "The Population Trap", pp. 121 ff., on the "child certificates" see p. 135 f.

maturity to have one legal child." Each person, both male and female, would receive, for instance, eleven decichild certificates at birth, and women would be able to accumulate certificates through marriage, to secure a birth rate of 2.2, or whatever number would ensure the reproductive rate the state was aiming at; in Boulding's times, the proto-normalistic ideal was ZPG – "Zero Population Growth".

The price of the certificate would be set by the market and would reflect the general desire in a society to have children. Boulding's was one proposition designed to "close the commons" in breeding, as the biologist Garrett Hardin demanded, striking at the "present policy of laissez-faire in reproduction".[39] "The general effect", Hardin commented Boulding, "would be to allocate child-permits as we now allocate Cadillacs – to the richest […]. But the scheme might be a useful interim measure in getting people used to the idea of parenthood as a licenseable privilege instead of a right."[40] Hardin's case demonstrates how the notion of the earth's ultimate "carrying capacity" – the asymptote of Pearl's logistic curve – involved a mathematical and a "moral economy"[41], inevitably resulting in fierce reasoning about who was to live and who was to die on a global scale.

Forecasting a Malthusian catastrophe for the year 1975, the brothers Paul and William Paddock in 1967 suggested applying a system of "triage" to rationally distribute U.S. food to poor nations.[42] "Triage" in military medicine meant assigning a priority of treatment to the wounded according to a classification of three to save the maximum number of lives: given limited medical facilities, the "can't be saved" are left to perish, the "walking wounded" will survive without immediate help, and only those who can be saved by immediate medical care are the ones that the doctors will attend to. The Paddock brothers' application of triage to nations adopted this first-aid rationality, demanding a choice between those nations who were

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39 In his famous *Science* article of 1968, "The Tragedy of the Commons", Hardin attacked the system of common goods, which, overloaded within a limited world, resulted in ever-rising resource scarcity and pollution. What he asked for was a "fundamental extension in morality", of a mutually agreed upon form of "Thou shalt not…" Hardin, Garrett, "The Tragedy of the Commons", *Science* 162 (1968) 3859, pp. 1243-1248, quotes p. 1248, 1244. "Thou shalt not exceed the carrying capacity" became his directive in the years to follow, with close reference to biblical authority. Hardin, Garrett, "Carrying Capacity as an Ethical Concept", in: Lucas, George R., Jr., Ogletree, Thomas W. (Eds.), *Lifeboat Ethics: The Moral Dilemmas of World Hunge*r, New York, Harper & Row 1976 (*Soundings*, 59 (1976)), pp. 120-137, quote p. 134.

40 Hardin, Garrett, *Exploring New Ethics for Survival. The Voyage of the Spaceship Beagle*, New York, The Viking Press 1972 [1968], p. 201. Compare Hardin, Garrett, "Editorial: Parenthood: Right or Privilege?" *Science* 169 (1970), p. 427. However, Hardin also criticizes too simple schemes: "I'm afraid there are more patterns of marriage and sex than are dreamt of in Doris Day's philosophy." Hardin, *Exploring New Ethics for Survival*, p. 192.

41 "Moral Economy" is a term which Lorraine Daston introduced to science studies; Daston, Lorraine, "The Moral Economy of Science", in: Thackray, Arnold (Hrsg.), *Constructing Knowledge in the History of Science*, (*Osiris*, Second Series, Vol. 10), 1995, pp. 3-2, referring back to E. P. Thompsen's use of the term.

42 Paddock, William, Paddock, Paul, *Famine – 1975!* London, Weidenfeld & Nicolson 1968 [1967], Chapter III. 9, p. 205 ff.

doomed to suffer the inevitable Malthusian catastrophic disaster, those who would be able to cope with overpopulation on their own, and those who should receive food for a chance overcome their crisis.[43]

Framing the situation as an arithmetic problem of distributing the wealthy nations' limited stocks preferred a mathematical to a political solution. Within this frame of discourse, the application of triage could appear as a reasonable procedure. Global power relations were left unnoticed and untouched; they were rather stabilized.[44] A similar demand for "population control" on a global scale was Hardin's concept of "Lifeboat Ethics". Hardin turned the image of the sinking ship, used to denote confinement and complete interdependence of life on earth, around to make a "Case Against Helping the Poor".[45] Arguing against the "fundamental error of the ethics of sharing" in international aid programs, he prompted the wealthy nations to close their doors to acts of charity like immigration and food aid to the poor, who would simply "convert extra food into extra babies".[46] Hardin suggested reaching the *optimum* population through a (Darwinist) process of selection according to a nation's "fitness", defined according to a classical liberalist and completely ahistorical logic of achieved prosperity.

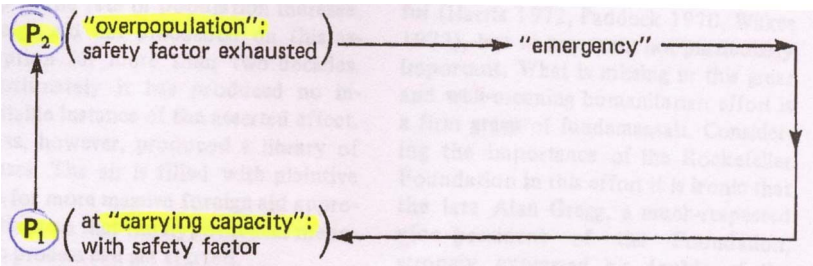

Fig. 1. The population cycle of a nation that has no effective, conscious population control, and which receives no aid from the outside. P_2 is greater than P_1.

An international food bank, he argued, would only be "a disguised one-way transfer device for moving wealth from rich countries to poor". In the absence of help from the outside, and without conscious population control, a nation's population would repeatedly go through a "population cycle", where the "emergency" of "overpopulation", would result in a drop-back to "the 'normal' level – the 'carrying capacity' of the environment – or even below". If, however, such countries were able to draw on world food bank resources in times of "emergency", the "normal population cycle", Hardin warned, would be replaced by the "population *escalator*". The input of food would act as "the pawl of a ratchet", pushing the

43 Ibid., pp. 206-207.

44 "The Time of Famines Can be the Catalyst for a Period of American Greatness". Ibid., p. 230.

45 Hardin, Garrett, „Lifeboat Ethics: The Case Against Helping the Poor", *Psychology Today* 8 (1974) 4, p. 38 ff., 123 ff. The longer text version is Hardin, Garrett, "Living on a Lifeboat", *BioScience*, 24 (1974) 10, pp. 561-568.

46 Hardin, "Living on a Lifeboat", pp. 561-568, quote p. 564.

population upward, a process brought to an end only by the total collapse of the whole system.[47] The process is represented by a composition of S-curves, which Link has termed the "ever growing snake".[48] It conveys the "thrill" of irreversible "denormalization", or, in Hardin's terms, of political "demoralization": "The crash is not shown, and few can imagine it."[49]

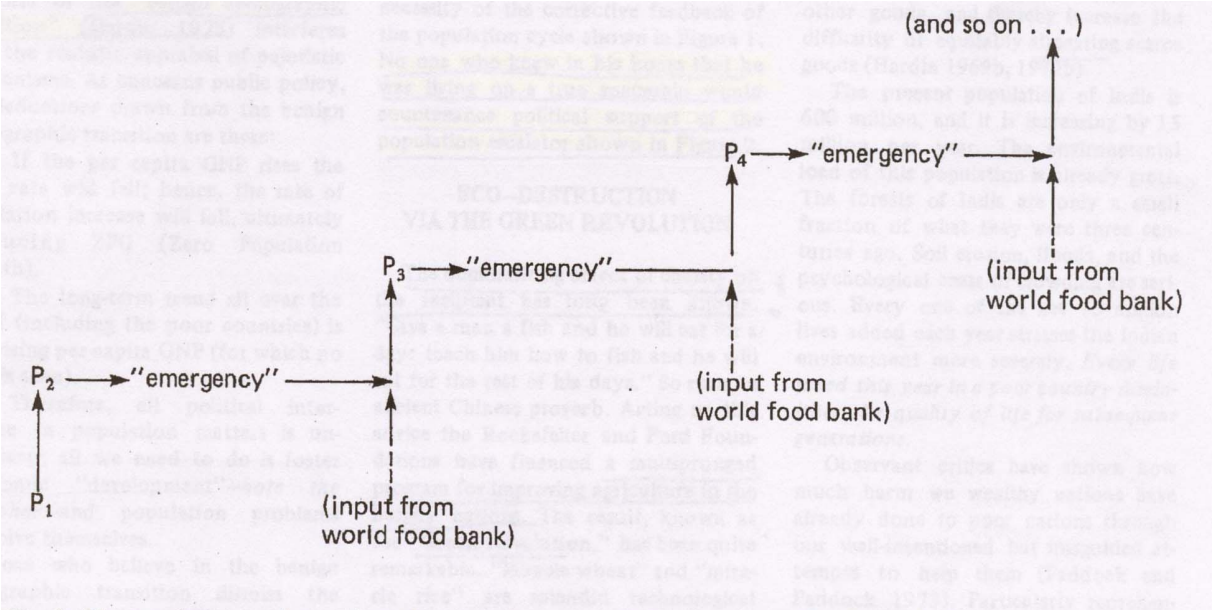

Fig. 2. The population escalator. Note that input from a world food bank acts like the pawl of a ratchet, preventing the normal population cycle shown in Figure 1 from being completed. P_{n+1} is greater than P_n, and the absolute magnitude of the "emergencies" escalates. Ultimately the entire system crashes. The crash is not shown, and few can imagine it.

Conclusion

In Hardin's terms, the "normal" refers to those nations not able to economize cleverly, consequently awaiting their punishment of heavy suffering. It seems that regulatory suggestions to overcome the "normal population cycle", which constantly produced surplus or "overpopulation", ultimately stabilized the mathematical construction of "normal population growth". Although they might seem strangely scandalous and even marginal today, the suggestions and effected regulatory measures to control population growth in the late 1960s and early 1970s merely followed a rigid and conservative accountancy logic still in effect. Moreover, in today's times of "population ageing and decline" in the North, growth has become the "standard" against which we have come to measure the state of the population and

47 Ibid., p. 564, his emphasis.

48 Link, *Versuch über den Normalismus*, p. 200: „endlos wachsende ‚Schlange'".

49 Hardin, "Living on a Lifeboat", p. 564; see also p. 565: "The demoralizing effect of charity on the recipient has long been known."

the economy. Hardin's "ratchet effect", once a warning of abnormal growth, today has become oddly common.

Figures

Fig. 1: "The S-Shaped Biological Growth Curve". Brown, Lester R., *The Twenty-Ninth Day. Accommodating Human Needs and Numbers to the Earth's Resources* (A Worldwatch Institute Book), New York, W. W. Norton 1978, p. 69.

Fig. 2: "World Population Growth". Sax, Karl, *Standing Room Only. The World's Exploding Population*, Boston, Beacon Press 1960 (orig. 1955: *Standing Room Only. The Challenge of Overpopulation*), p. 35.

Fig. 3: "Population Growth During 700 Years, With a Doubling Time of 50 Years". Forrester, Jay W., *World Dynamics*, Cambridge, Mass., Wright-Allen Press 1971, p. 3.

Fig. 4: "Population Growth, Plotted to Scale". Forrester, Jay W., *World Dynamics*, Cambridge, Mass., Wright-Allen Press 1971, p. 4.

Fig. 5: "The Logistic Curve and its First Derivative". Pearl, Raymond, „The Biology of Population Growth", in: Sanger, Margaret (Hrsg.), *Proceedings of the World Population Conference, held at the Salle Centrale, Geneva, August 29th to September 3rd, 1927*, London, Edward Arnold & Co. 1927, pp. 22-38, p. 27.

Fig. 6: "The Growth of the Population of the World". Pearl, Raymond, *The Biology of Population Growth*, New York, Alfred A. Knopf 1930 (revised edition, orig. 1925), p. 173.

Fig. 7: "The Population Bomb Keeps Ticking". Ehrlich, Paul R., *The Population Bomb*, New York, Ballantine 1968, title page.

Fig. 8: "Population *Behavior Modes*". Meadows, Donella H., Meadows, Dennis L., Randers, Jørgen, Behrens, William W. III, *The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind*, New York, Universe Books 1972, pp. 91-92.

Fig. 9: "World Model Standard Run". Meadows, Donella H., Meadows, Dennis L., Randers, Jørgen, Behrens, William W. III, *The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind*, New York, Universe Books 1972, p. 124.

Fig. 10: "The Normal Population Cycle". Hardin, Garrett, "Living on a Lifeboat", *BioScience*, 24 (1974) 10, pp. 561-568, p. 564.

Fig. 11: "The Population Escalator" ("Ratchet Effect"). Hardin, Garrett, "Living on a Lifeboat", *BioScience*, 24 (1974) 10, pp. 561-568, p. 564.