Reprinted from Science, April 13, 1962, Vol. 136, No. 3511, pages 173-174

"Projections" versus "Forecasts" in Human Population Studies

Dorn, in his recent article about human population growth (*1*), has credited our work on the same subject (*2*, *3*) as setting "a record, for the entire class of forecasts prepared by the use of mathematical functions, for the short length of time required to demonstrate its unreliability."

According to Dorn, a happy contrast to this method which he describes as "the extrapolation of mathematical curves fitted to the past trend of population increase" is the "analytical approach," which he assures us by no means tries to make a forecast ["to estimate or calculate in advance" (*4*)], but gives "merely indications of the population that would result from the hypothetical assumptions concerning the future trend in fertility, mortality, and migration. However, the projections of fertility, mortality, and migration usually are chosen to include what the authors believe will be the range of likely possibilities. . . ." This he properly points out is called a "projection" ["to send forth in one's mind or imagination" (*4*)]. He states that "the most authoritative projections of the population of the world are those made by the United Nations."

A comparison of the "most authoritative" with the "most unreliable" method is given in Table 1, which lists the United Nations projections (*5*) made during the past decade for, as an example, the year A.D. 2000, together with the values computed from Eq. 11 of our article (*2*).

From Table 1 it appears that the "most unreliable" values are just the asymptotes, at the moment of truth, to the "most authoritative projections"; we might mention in passing that the "most authoritative" projectors changed their minds in the last decade by roughly a factor of 2, while the "most unreliable" values (from Eq. 11) are almost independent of the time of their derivation, as was pointed out in our article (*2*).

The question remains as to what causes the "analytical" method to be so poor in making even short-range projections. The answer is suggested by Dorn, who stresses the point that this method of dealing with a growth process takes into consideration instantaneous first derivatives only—fertility, mortality, and migration. However, it is well known in prediction theory (*6*) that consideration of higher derivatives will diminish the variance in the expectation values. For instance, we could not catch a ball in flight if we were unable to compute at least its trajectory's second derivative, which happens, in this case, to be a constant. On the other hand, computation of higher and higher derivatives requires more and more data regarding the process under consideration, which can, by the blind ones whose vision of the future is blocked, be obtained only by studying the past! This simple procedure is, alas, unacceptable to the "analyticist," to whom the past is, for unexplainable reasons, tabu.

In spite of these disagreements in method we are in full agreement with Dorn's conclusions that "man's ability to control his environment" can avert a population catastrophy "provided he rapidly develops cultural substitutes for those harsh but effective governors of his high reproductive potential," because his suggestion is precisely our thesis. We observed that the growth phenomenon of the human population in the past is typical of an open-loop system that is composed of cooperative elements following a superadditive composition rule. An intrinsic instability of such systems, which manifests itself in a pathologically rapid growth, can be avoided by converting the open-loop system into a closed-loop system. Hence, we suggested a "population servo," which, first of all, has to provide a feedback that informs the system of its present state. Dorn's paper serves our purpose admirably.

HEINZ VON FOERSTER
PATRICIA M. MORA
LAWRENCE W. AMIOT
Department of Electrical Engineering, University of Illinois, Urbana

Table 1. Low, medium, and high world-population projections (in billions) for A.D. 2000, made by the U.N. in four different years and derived from Eq. 11 of our article (*2*): $N = 1.78 \times 10^{11}/(2027 - t)^{0.99} \pm 7$ percent.

Projection	N (U.N. values)				N from Eq. 11
	Year of estimate				
	1950	1957	1958	1959	
Low			4.88		6.44
Medium	3.20	5.00	5.70	6.20	6.91
High			6.90	~7.00	7.40

References

1. H. F. Dorn, *Science* **135**, 283 (1962).
2. H. von Foerster, P. M. Mora, L. W. Amiot, *ibid.* **132**, 1291 (1960).
3. ———, *ibid.* **133**, 943 (1961); **133**, 1932 (1961).
4. *Webster's New World Dictionary of the American Language* (World Publishing Co., Cleveland, college ed., 1959).
5. *U.N. Publ. No. St/SOA/Ser. A/17* (1953); *U.N. Preview* **4** (July 1957); *U.N. Population Bull. No. 14* (1958); *U.N. Population Bull. No. 15* (1959).
6. N. Wiener, *Extrapolation, Interpolation, and Smoothing of Stationary Time Series* (Wiley, New York, 1950).