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PREFACE

The value of population projections is no longer disputed. It is now commonplace that, if a plan for social and economic development is to have any chance of realistic implementation, it requires a parallel assessment of the dynamics of population growth. Likewise, when told that the world's population may rise from 2,500 million to 4,000 million during the next twenty-five years, we think at once of the direct practical consequences in the economic and social sphere. And yet such a statement should stimulate even more profound thought : we should do well to ponder the significance of this development in terms of the destiny of our species.

These next twenty-five years form part of a process which began some 200,000 years ago and which is about to culminate in man's full possession of the earth.

Two hundred thousand years ago, an extraordinary event occured, as important perhaps in its outcome as the appearance of the first living cell : a creature which morphologically probably hardly differed from the other primates surrounding it, crossed the threshold of deliberate reflection; man had quietly entered the scene.

The consequences of this event were not at once apparent; moreover, this first man was a mere semblance of what man is today. Palaeontology traces the stages of that evolution, and we now have a fairly clear idea of the process whereby, during these 200,000 years, the *homo faber* of the early quaternary age developed into the *homo sapiens* of today's demography. Palaeontology is concerned with periods of the order of two hundred thousand years and, though man eventually emerges as the dominant figure in that evolution, he does not appear, at least at the outset, to have materially altered the rate of change in the varying forms of life.

Yet, while it took 200,000 years for the world's human population to reach 2,500 million, it will now take a mere thirty years to add another 2,000 million. With the present rate of increase, it can be calculated that in 600 years the number of human beings on earth will be such that there will be only one square metre for each to live on. It goes without saying that this can never take place, something will happen to prevent it.

We are now speaking of 600 years, whereas just now we were talking of periods 200 times as long. Six hundred years is a little more than the time that has elapsed since the discovery of the New World. We have left palaeontology for history; the natural evolution of man is virtually completed. A new process is about to begin, or has perhaps already started, and the first signs of that " socialization " of the world which appear on the horizon may be significant in this connexion. Our previous view that the crossing of the " threshold of thought " had not altered the rate of evolution no longer holds. Deliberate thinking, in fact, has so increased this rate that the very nature of the evolutionary process has been thereby changed and that is seems imperative having created the means of accelerating it, to find also the means of slowing it down and recovering equilibrium. Yet the danger of such remedial action is obvious. As long as it was a question of increasing the population, we were part of the stream followed by evolution during millions of years. Faced with the problem of checking this growth, we are swimming against the tide and, in extremity, having discovered how to increase the flood waters we now also possess the means of arresting them. It now depends on us whether this awakening of consciousness within the stream of life ends in failure or success. If tomorrow mankind loses the desire to live or, more correctly, to survive, the history of life on earth will have lost all meaning. This explains why those who have undertaken to be the custodians of man's moral heritage are questioning his moral preparedness to govern his own destiny.

The growth of world population during the next twenty-five years, therefore, has an importance which transcends economic and social considerations. It is at the very heart of the problem of our existence. We should like the reader to keep this idea before him in considering the facts and conjectures which follow.

INTRODUCTION

Mindful of the needs of various offices of the United Nations and governmental and private institutions, the United Nations Population Branch is continuously engaged in the preparation of future population estimates for countries, regions, and the world as a whole. These estimates are not the result of simple routine, and their continued improvement depends on the development of appropriate methods.

The latest available information, and the methods described further on, have now resulted in estimates of world population, for the second half of this century, which are considerably higher than have been envisaged before. Properly interpreted, this result has grave implications for the planning of the economic and social well-being of future generations. A discussion of this result, however, is apt to be misleading until the conditions under which it is most likely to be realized have been explicitly stated. This makes it indispensable to describe, first of all, the methods by which it has been arrived at. Once the methods have been explained, some of the implications will be considered.

The calculating methods used for the present purpose are an innovation from those used in earlier attempts to assess world population trends. Though rough and simple, this new calculating system is of much theoretical and practical interest, as is shown further on. In the first chapter of this report, the methods are described, the resulting figures of total population are discussed in the second chapter, and expected changes in birth rates, death rates and age structure in the third. The last chapter presents the theoretical aspects of the population types implied in the calculating models. The models, certain tests of their adequacy, and calculated numbers of future population appear in the appendix.

The new results differ from those of previous estimates of future world population made by the United Nations. A comparison of the earlier results with those obtained now forms part of this introduction.

Comparison with previous estimates of world population in 1980

Two previous attempts of the United Nations to estimate future world population have been published.[1] On both occasions, the calculations were carried out for a period up to 1980, on high, medium and low assumptions.

The estimates prepared in 1951 were relatively simple. The population of the world was divided into three parts, and for each part seemingly plausible changes in average birth rates and death rates were conjectured. The resulting estimated world total, for 1980, according to the three assumptions, ranged between 2,976 and 3,636 million, the difference between the figures being 660 million.

In 1954, five sets of varying and flexible assumptions were worked out and applied separately to each of twenty-five world regions. The assumptions conformed to a scheme in which it was implied that, in the course of time, demographic conditions of one type are likely to be superseded by conditions of another type. Up-to-date statistical information could not be secured in respect of certain regions, for which admittedly arbitrary estimates had to be substituted. On this basis, the world population of 1980 was estimated between 3,295 and 3,990 million, a range of 695 million.

On the basis of improved information and more detailed methods, the present calculations result, for the year 1980, in a low estimate of 3,850 million and a high estimate of 4,280 million, a range of 430 million.

The first fact to be noted is that estimates have been revised upward. Even the low estimates obtained now are near the high figures estimated in 1954, and clearly outside the range of estimates made in 1951. This rapid and extensive revision gives ground for questioning whether the attempt of estimating future world population is not being continuously defeated. The explanations offered below show that there are good reasons to attach greater confidence to the most recent results than to those calculated before.

It will also be noted that the range between the two extreme figures has narrowed, from 660 million in 1951 and 695 million in 1954, to 430 million now. In part, this can be ascribed to the fact that the year 1980 is no longer so far off now as it was previously. To a large part, it is also a reflection of the somewhat increased confidence in our ability to estimate future demographic trends. Moreover, whereas a series of medium estimates was previously placed approximately half-way between the high and the low series, it is now considered probable that population growth will conform more nearly to the high than the low assumptions, and the medium estimates are placed much nearer the high than the low estimates.

[1] " The Past and Future Growth of World Population — A Long-Range View ", *Population Bulletin of the United Nations*, No. 1, December 1951; and " Framework for Future Population Estimates, 1950–1980, by World Region ", *Proceedings of the World Population Conference, 1954* (United Nations publication, Sales No.: 1955.XIII.8 (vol. III)), pp. 283–328.

Reasons for upward revision

The largest single factor which has determined upward revisions of both current and future world population estimates is the result of the 1953 population census on the Chinese mainland, of which a critical account has now been furnished.[2] Previously, the latest available official estimate of the population of China (including Taiwan) had been for 1948, and had amounted to 463 million. In 1953, 583 million inhabitants were ascertained to be on the mainland. This difference of more than 100 million at two dates only five years apart affects substantially the estimate of world population for the year 1950.

The effect of this new information on future estimates of total world population is even greater. When China's population was being assessed at a smaller figure, the estimate also implied that past and probable future population growth in China is slow. It has now been established that population in China is growing at a substantial rate, and the expectation is that future growth will likewise be rapid, contributing greatly to the increase in the population of the world.

Other reasons for upward revision stem from observations made since the end of the Second World War, a comparatively undisturbed period, for which the experience in 1951 and 1954 was then rather short, but has since accumulated. Among the facts which appear now more certain than previously are the following: (1) current and future declines in mortality are likely to be substantial; (2) birth rates in countries of high fertility are not very likely to decrease very soon; and (3) in most countries of comparatively low birth rates, renewed decreases in fertility do not appear imminent. This change in judgement does not affect high and low assumptions, but has altered the point of view in respect of the medium assumptions. The latter, in most instances, are allowed to coincide with the high up to 1975, and to deviate from them only for the remaining portion of the century.

The effect of these new data and considerations on population estimates can be further illustrated by comparing the figures estimated, on each occasion, for the three " groups of world regions " distinguished when the calculations were carried out for the first time. The several estimates for 1950, and the high estimates for 1980 are brought together in table 1.

The figures for 1950 have remained unchanged in the case of Group I. The statistics on population of countries within this group are, for the most part, always up to date and quite reliable. The figure for Group II was diminished in accordance with a recent publication of official statistics on the Soviet Union. Changes in figures for Group III are mostly the result of the use of different estimates on China: in 1951, the available 1948 figure was used; in 1954, the arbitrary estimate of 500 million was substituted; now the estimate is based on the 1953 census results.

Because of a new approach to the medium assumption, medium estimates for 1980 are now in all cases higher than those which were made before. Since, in most instances, the new medium assumption deviates from the high only from 1975 onward, it is more useful to compare the various high estimates made on the several occasions. Though estimating methods were different each time, the high estimates for the total of Group I areas have remained practically unchanged. Those for Group II have been diminished, partly because the current size of the population of the Soviet Union was previously over-estimated, and partly because of the continued decline in Japanese birth rates. The large increase in future population estimates for Group III is chiefly a result of revisions as regards the size and the rate of growth of the population of China.

[2] Ta Chen, " New China's Population Census of 1953 and its Relation to National Reconstruction and Demographic Research ", paper presented to the 30th Session of the International Statistical Institute, Stockholm, 8–15 August 1957.

TABLE 1. ESTIMATES OF POPULATION IN 1950 AND 1980 WHICH HAVE BEEN PREPARED BY THE UNITED NATIONS SECRETARIAT IN 1951, 1954, AND 1957, FOR THREE GROUPS OF WORLD REGIONS (IN MILLIONS)

Area	*Population in 1950 Estimates prepared in*			*High estimate for 1980 Estimates prepared in*		
	1951	*1954*	*1957*	*1951*	*1954*	*1957*
World total	2 406	2 454	2 500	3 636	3 990	4 280
Group I: Northern America; North, West, Central and Southern Europe, Oceania	486	486	486	655	656	652
Group II: Latin America; Japan; Eastern Europe and USSR	533	533	519	938	918	893
Group III: Rest of Asia; Africa	1 387	1 435	1 495	2 043	2 418	2 735

For these reasons, there should be no cause for surprise with estimates of world population amounting to 6,000 or 7,000 million by the end of our century.

Chapter I

THE METHODS

The methods developed for the present report involve several steps, an attempt being made to weld together the results of actual observations on population trends with those which can be calculated from theoretical population models.

Most countries supply the United Nations with current population estimates, but this information is not complete, nor are the criteria of the data always the same. The United Nations, accordingly, makes those auxiliary estimates which permit, so far as possible, comparable measurement of population growth among the regions of the world. Results so obtained for the 1950–1955 period, presented in part A below, will be regarded as the observed rates of population growth.

Observations on trends in total population over a brief period do not suffice for an adequate assessment of inherent tendencies. Furthermore, the statistics on births, deaths and migration (in any case not available for all regions), cannot be readily summarized with the simplicity needed for the present purpose. Generalizations on these vital trends, therefore, had to be made somewhat independently of the mass of available statistical detail. Some of the reasoning involved in this step is given in part B of this chapter.

Suitably combined, these generalizations lead to a scheme of populations models, briefly described [1] in part C. As applied to particular regional populations for given time periods, the models yield theoretical rates of population growth. In part D of this chapter, it is shown how a reconciliation can be made of these theoretical rates of growth with the observed rates presented at the beginning. After suitable adjustment of the models, future growth in regional populations consistent with current observed rates, can be calculated [2].

Population estimates for individual countries, though of a low order of reliability, have also been calculated as a by-product of the present scheme in the manner described in another part of this chapter. A critical note has been added on the uses and limitations of all the estimates which have been obtained.

A. Observed population growth in world regions, 1950–1955

For present purposes, nineteen world regions have been delimited in accordance with widely accepted geographic criteria. They have been drawn up chiefly with a view to meeting the requirements of most users of regional population estimates. The differentiation between these regions has not been based initially on their population trends, and conditions among and within each of the several countries composing a region are not uniform.

As defined, the regions are made up of the following countries and territories:

Northern Africa. Algeria, Ceuta and Melilla, Egypt, Libya, Morocco, Spanish West Africa, and Tunisia.

Middle Africa. Angola, Belgian Congo, Cameroons (Br. Admin.), Cameroons (Fr. Admin.), Cape Verde Islands, Comoro Islands, Empire of Ethiopia, French Equatorial Africa, French Somaliland, Togoland (Fr. Admin.), French West Africa, Gambia, Ghana, Kenya, Liberia, Madagascar, Mauritius, Mozambique, Nigeria, Portuguese Guinea, Reunion, Rhodesia and Nyasaland, Ruanda-Urundi, St. Helena, Sao Tome and Principe, Seychelles, Sierra Leone, Somaliland (It. Admin.), Somaliland Protectorate, Spanish Guinea, Sudan, Tanganyika, Uganda, and Zanzibar and Pemba.

Southern Africa. Basutoland, Bechuanaland, South West Africa, Swaziland, and Union of South Africa.

Northern America. Alaska, Bermuda, Canada, Greenland, St. Pierre and Miquelon, and United States of America.

Central America. British Honduras, Canal Zone, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama.

Caribbean. British West Indies, Cuba, Dominican Republic, Guadeloupe, Haiti, Martinique, Netherlands Antilles, Puerto Rico, and Virgin Islands (U.S.).

Tropical South America. Bolivia, Brazil, British Guinea, Colombia, Ecuador, French Guinea, Peru, Surinam, and Venezuela.

Temperate South America. Argentina, Chile, Falkland Islands, Paraguay, and Uruguay.

South-West Asia. Aden Colony and Protectorate, Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait,

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[1] The theoretical models, conceived as a scheme of populations of various types, can serve many purposes in addition to the calculation of future population totals; because of their considerable theoretical interest, they are examined in further detail in chapter IV.

[2] The unadjusted models are by necessity an oversimplification of the precise demographic situations which exist in those regions of the world to which they are being applied. The extent to which they approximate to actual conditions in every part of the world is examined in the "Note on the adequacy of the models as applied to particular regions", appended to this report.

Lebanon, Muscat and Oman, Ghaza Strip (Palestine), Qatar, Saudi Arabia, Syria, Trucial Oman, Turkey, and Yemen.

Central South Asia. Afghanistan, Bhutan, Ceylon, India, Maldive Islands, Nepal, Pakistan, and Portuguese India.

South-East Asia. British Borneo, Burma, Cambodia, Indonesia, Laos, Malaya, Philippines, Portuguese Timor, Singapore, Thailand, Viet-Nam, and West New Guinea.

East Asia (without Japan). China (mainland), China (Taiwan), Hong Kong, Korea, Macao, and Mongolian People's Republic.

Japan area. Japan, and Ryukyu Islands.

Northern and Western Europe. Belgium, Channel Islands, Denmark, Finland, France, Iceland, Ireland, Isle of Man, Luxembourg, Monaco, Netherlands, Norway, Sweden, and United Kingdom.

Central Europe. Austria, Czechoslovakia, Germany, Hungary, Liechtenstein, Poland, Saar, and Switzerland.

Southern Europe. Albania, Andorra, Bulgaria, Gibraltar, Greece, Italy, Malta and Gozo, Portugal, Romania, San Marino, Spain, the Vatican, and Yugoslavia.

Australia and New Zealand. Australia and New Zealand.

Pacific Islands. American Samoa, British Solomon Islands, Cook Islands, Fiji, French Oceania, Gilbert and Ellice Islands, Guam, Hawaii, Nauru, New Caledonia, New Guinea (Australian admin.), New Hebrides, Niue, Norfolk Island, Pacific Islands (U.S. admin.), Papua, Tokelau Islands, Tonga, and Western Samoa.

USSR. The Union of Soviet Socialist Republics.

Population estimates for these regions are presented in table 2. The estimates are based, for the most part, on official figures, though modified in various ways. The attempt has been made to arrive at comparable estimates of *de facto* (present-in-area) total population as of mid-year 1950 and mid-year 1955, so far as available evidence permits [3]. It does not follow that the rates of population growth from 1950 to 1955 have in all instances been correctly estimated. The 1950–1955 growth rates are affected by inherent tendencies, of unknown magnitude, in official post-censal estimates, either to exaggerate or to minimize population growth since the last census. Estimates which have been further adjusted or are not based on censuses reflect the assumptions which had to be made in their calculation.

[3] To this end, categories of the population not included in official estimates, such as merchant seamen at sea, nomadic tribes, or a fraction of the population believed to have been omitted in the census enumeration, had to be added in. Where official figures for the precise dates were not available, suitable estimates had to be interpolated or extrapolated. A few estimates had to be made on the basis of separate research. While the estimates for some of the individual countries may be in substantial error, the importance of these errors relative to the regional totals shown in the table, in most instances, is probably not very great. To avoid an undue impression of accuracy, the figures in table 2 have been rounded to three significant digits.

In this connexion, it is to be noted that numerous censuses have been taken in, or near, the year 1950. Estimates for 1950, therefore, are somewhat more directly related to indeperdent measurement than are estimates for 1955, the majority of which are affected by errors common to all post-censal population figures. Some of these result by addition to a previous census total of registered births, and subtraction of registered deaths (with, or without adjustment for migration),

TABLE 2. ESTIMATED POPULATION OF REGIONS, CONTINENTS AND THE WORLD MID-YEAR 1950 AND 1955, AND PER CENT INCREASES, IN 1950–1955. *(populations in millions, rounded to three significant digits)*

Region and Continent	*1950*	*1955*	*% increase 1950-1955* [a]
Northern Africa	42.7	47.3	10.54
Middle Africa	142	153	7.99
Southern Africa	13.9	15.3	9.78
TOTAL AFRICA	199	216	8.66
Northern America	168	183	8.84
Central America	34.7	40.0	15.35
Caribbean	16.3	17.8	9.05
TOTAL NORTH AMERICA	219	240	9.88
Tropical South America	84.4	94.6	12.15
Temperate South America	27.2	30.0	10.33
TOTAL SOUTH AMERICA	112	125	11.70
South-West Asia	63.3	71.6	12.96
Central South Asia	466	499	7.15
South-East Asia	171	186	8.56
East Asia (without Japan)	595	641	7.83
Japan area	83.6	89.9	7.54
TOTAL ASIA [b]	1,380	1,490	7.91
Northern and Western Europe	133	137	2.59
Central Europe	128	134	4.79
Southern Europe	132	138	4.75
TOTAL EUROPE [c]	393	409	4.03
Australia and New Zealand	10.2	11.5	12.27
Pacific Islands	2.93	3.26	11.34
TOTAL OCEANIA	13.2	14.7	12.06
USSR	181	197	8.84
WORLD TOTAL	2,500	2,690	7.79

[a] Calculated from population figures to the nearest thousand; for the calculation of these rates of increase, fictitious population figures for 1950 have been substituted in the case of a few countries to eliminate the effects of abnormal events on population growth during the 1950–1955 period.

[b] Excluding the Asian part of the USSR.

[c] Excluding the European part of the USSR.

though births and deaths are not registered with the same degree of completeness. Other post-censal estimates reflect a debatable assumption that a rate of growth observed in some earlier period continues to apply in the period following the census. The rates of growth shown in table 2 are largely affected by these several methods by which current population figures are derived from a previous enumeration.

The rates of growth would deserve greater confidence if they were calculated for a base period long enough so that in many, if not most, instances at least two censuses might have been taken. This will become possible at some time in the future, since many countries in the world plan to take their next censuses in and around the year 1960. For the time being, a longer base period could have been taken by going further into the past, prior to the year 1950. But this would not have served a useful purpose. During the period of the Second World War, periodic censuses had to be left in abeyance in many countries. Furthermore, during the war, as well as for several years afterwards, conditions affecting population growth were decidedly abnormal in many parts of the world, thus providing a very inadequate clue for the population trends which, under more normal conditions, should be expected in the future. The evidence of population estimates for 1950 and 1955 is, perhaps, the best available now for the given purpose though, of course, it is imperfect in several respects.

It is true that unusual events, unlikely to recur, have also affected the population growth of some countries (e.g., Israel, Korea, or Viet-Nam) during the 1950–1955 period. To avoid the effect of such events on the estimated rates of population growth, and to obtain rates representing normal conditions, it was necessary to substitute, for some countries, adjusted estimates for the year 1950 such that, had these events not occurred, the estimated population for 1955 would have been the result of normal population trends. The artificial figures which had to be used for 1950 in the case of some countries, however, have had comparatively little effect on the regional totals.

B. Conditions underlying population growth in various parts of the world

It is not to be expected that the rates of population growth observed in the 1950–1955 period — apart from the effects of certain unusual events — will continue without change. The exact manner in which they will change cannot be foreseen, but certain general considerations indicate the direction in which changes in particular regions are likely to occur.

The considerations presented below have led to detailed assumptions relating to trends in fertility and mortality in population models with which the several regional populations can be roughly assimilated.

These assumptions have not been formulated in terms of *crude* birth and death rates only [4], since these depend in part on population age structure, which itself results from birth and death rates in the past. The models have been calculated, age group by age group, with the methods which are appropriate to detailed population projections, by sex and age. The variable factors in these models are general levels of mortality, as summarized by expectation of life at birth and characterized by model life tables, and general levels of fertility, summarized by a simplified measure of gross reproductivity.

It is true that migration also plays a part in population change, but this factor will be partly accounted for only at a later stage in the procedure.

A given current level of mortality and of fertility describes a demographic situation. To some extent, the situation also depends on past trends, because of their effects on age structure. In each given situation, certain types of future trends appear to be the most likely ones. Models had therefore to be elaborated which fitted most nearly the major demographic situations now prevailing in various parts of the world [5].

A brief review [6] of typical conditions underlying mortality and fertility trends, therefore, is necessary before we proceed to a more detailed description of the models.

1. *Mortality*

Decline in mortality is now an almost universal phenomenon. Evidence of a firm trend of falling death risks can be established with certainty for the great majority of world regions. Because of the availability of cheap and effective means of disease control, mortality may now decline rapidly even if it is initially high. Only two extreme situations seem to present exceptions to this rather general rule.

In some areas of the world, remoteness from the centres of administration, difficult physical access, and certain cultural barriers still impede progress in the propagation of modern life-saving devices. Difficulties of this type seem to prevail in large parts of Middle Africa where it is as yet uncertain whether modern health measures have had much impact on the high rates of mortality, or whether they are likely to produce any conspicuous results within the near future. The same may also be true of remote population groups in other regions of the world, but the numbers involved in areas outside Africa are comparatively much smaller. Nevertheless, the modicum of administrative control already established effectively prevents much of the internecine strife and other recurrent disasters which, in earlier times, sometimes exacted huge tolls in human lives. Such observations as have been made, and some theoretical considerations, lead to the view that the expectation of life in Middle Africa may approach 30 years, but is not very likely to rise much above this figure within the near future.

[4] i.e., the annual numbers of births, or deaths per 1,000 inhabitants.

[5] The goodness of the fit is examined more closely in the Note presented in appendix A.

[6] A more extensive survey has been published elsewhere : see " World Population Trends ", in *Report on the World Social Situation* (United Nations publication, Sales No. : 1957.IV.3), chapter II, pp. 5–27.

The other extreme situation is one where mortality is already so low that, in the present state of knowledge and available facilities, further progress must of necessity be slow. In several regions, life expectancy now considerably exceeds 60 years, while in some countries the figure of 70 years has been attained or surpassed. Further gains are to be expected, but there is no immediate prospect that the expectation of life can rise very much above 75 years. Even if it should, the effect on crude death rates would in any case be very slight. Conditions of this type exist, or are likely to be attained soon, in Northern America, Argentina, Japan, the three regions of Europe, Australia and New Zealand, and the Soviet Union.

Between these extremes are the populations of regions where mortality, whether high or moderate, can be expected to decline quite rapidly. The regions of very high mortality, where until quite recently average expectations of life have hardly exceeded 30 years, comprise South-West Asia, Central South Asia, South-East Asia, and East Asia (without Japan). Somewhat lower mortality probably prevails among a majority of the populations of Northern Africa and Southern Africa. Average expectations of life near 45 years, for recent periods, can be estimated for Central America and Tropical South America.

In view of these considerations and findings, the following mortality situations are of interest for the models :

(*a*) Constant mortality, with expectation of life near 30 years;

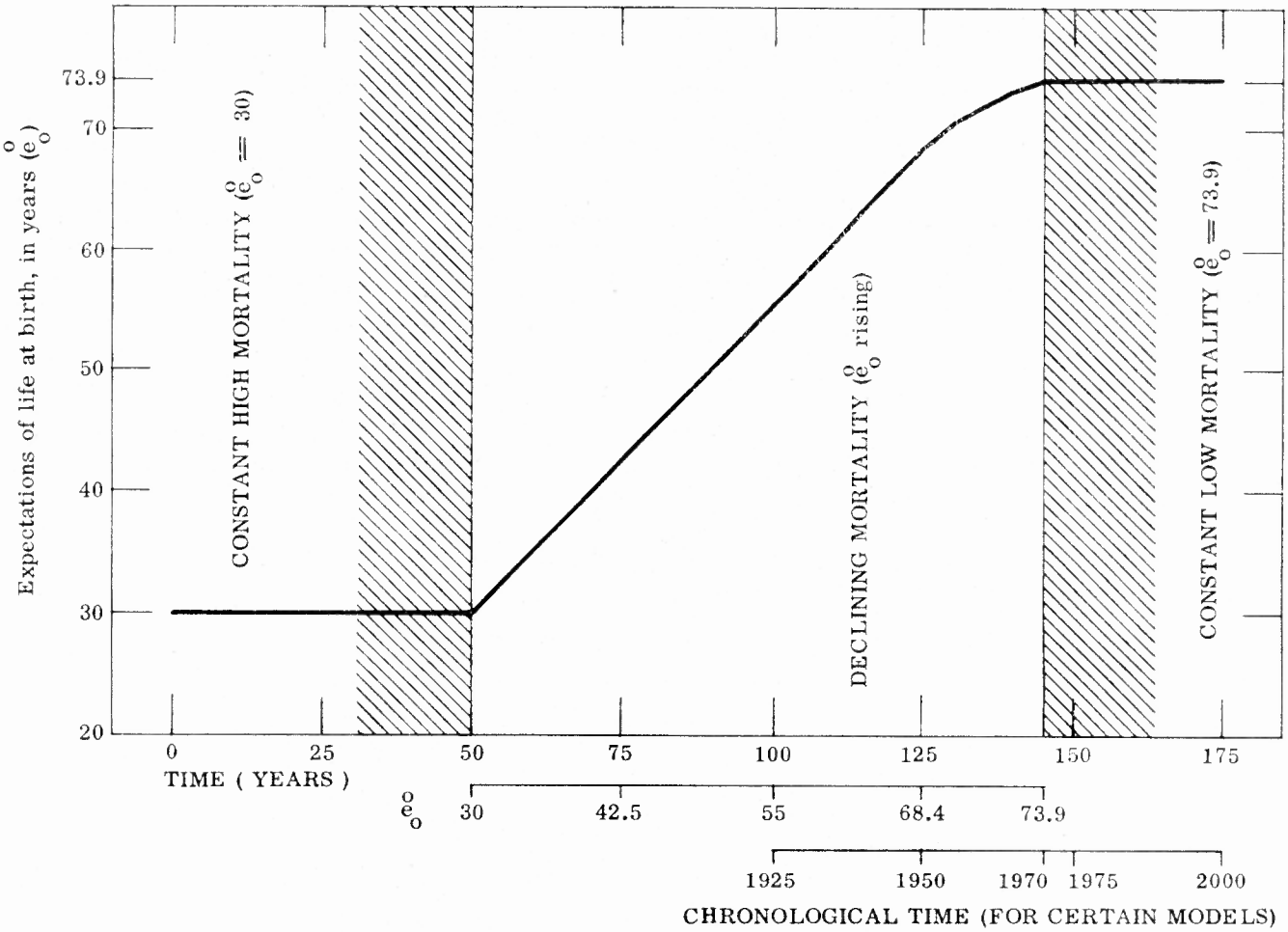
(*b*) Declining mortality, expectation of life rising continuously, eventually to attain almost 75 years; and

(*c*) Eventually constant mortality, once an expectation of life approaching 75 years has been reached.

With respect to the particular regions, this characterization is, at best, only very approximate [7]. At this time, and for a considerable time in the future, the second of these situations will be the most common one, though mortality decline may be more rapid in

[7] The assumptions used for the models will be tested with reference to available statistics in chapter III.

CHART I. CURVE OF RISE IN EXPECTATION OF LIFE, IN THE COURSE OF TIME, AS USED IN THE POPULATION MODELS



some areas than in others. Since the detailed conditions in every area could not be studied, and for the sake of simplicity, the decline of mortality in all areas was assumed to conform to a uniform pattern, which is roughly borne out by recent studies of mortality changes during the past half-century [8]. The only major area for which there is as yet no evidence of a firm trend towards decreasing death risks is Middle Africa.

As indicated by various studies, progress in the prevention of deaths, at any given level of mortality, has been increasingly rapid during the present century. An annual gain of half a year in the expectation of life at birth is now normal, at least for expectations of life ranging from 30 to 55 years. From 55 to 65 years, the annual gain in expectation of life can be slightly more rapid since it is usually at this level that there is a remarkably swift decline in infant and child mortality. Beyond 65, the expectation of life is likely to rise at a progressively slower pace, and further additions in the expectation of life become rather small, once an expectation of 70 years has been surpassed [9].

Progress in the expectation of life can, therefore, be associated uniformly with a fictitious time sequence. Since, for many of the population models used here, it is assumed that an expectation of 68.2 years is reached in 1950, part of the sequence can also be associated with chronological time. The fictitious time sequence of mortality is an ingredient of all population models in this study and is illustrated in chart I comprising one section where expectation of life remains constant at 30, another section where it rises (regularly up to 55, more rapidly to 65, and then progressively less rapidly to 73.9), and a third section where it is constant at 73.9. Reference to chart I will facilitate the interpretation of charts II to V in which the models are defined in terms of fertility, mortality, and a time sequence.

2. *Fertility levels*

Among large populations in the world, reliably recorded birth rates range between 15 and 50 per 1,000, which corresponds to ranges in the gross reproduction rate between 1 and slightly more than 3.

Gross reproduction rates of the order of 3, with relatively minor variations, are typical of a majority of the world's populations, and the available evidence [10] indicates that approximately the same level of reproductivity has prevailed in these populations over long periods of the past. In many instances, where available evidence is deficient, it remains justifiable to presume that gross reproduction is approximately at this same level [11]. The three regions of Africa, those of Central and Tropical South America, and the Asian regions other than Japan, all seem to conform, in a rough approximation, to this pattern, even if the conditioning factors are not necessarily always the same [12].

While gross reproduction rates of very nearly 3 are most wide-spread, fairly stable levels of the order of 2 1/4 have also been noted in such culturally diverse situations as parts of the Caribbean, Japan prior to 1930, and much of Europe before the end of the last century. These levels, although lower than those of more than half the world's population, have been fairly stable over considerable periods of time.

A relatively stable level of fertility, therefore, seems to reflect cultural attitudes surrounding the constitution of families which are often highly resistant to change. This makes it not unreasonable to suppose that, once a significant change has occurred and has run its full course, there will be a renewed tendency for fertility to stabilize, though at a quite different level. This supposition seems to find support in the recent trends of fertility of many Western countries for most of which, the period of observation unaffected by severe disturbance (generally only since 1947 or 1948) is still rather short. Only in one country, Argentina, gross reproduction at the level of 1 1/2, with very little change, has been observed for as long as 25 years.

The view that fertility in Western countries may remain fairly stable finds additional support from the fact that there has been some recent convergence of fertility levels from previously quite diverse positions. In most of Europe, according to observed birth rates, the gross reproduction rate is not very far from about 1 1/4. In countries of European settlement, notably Argentina, Australia, Canada, New Zealand, the United States, and the Soviet Union, gross reproduction rates are now generally of the order of 1 1/2. Yet only about 20 years ago fertility in Western Europe and Northern America was extremely low, while it was still rather high in Southern Europe and the Soviet Union.

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[8] Notably George J. Stolnitz, "A Century of International Mortality Trends", *Population Studies* (London), July 1955, pp. 24–55, and *ibid.*, July 1956, pp. 17–42. Also: *Age and Sex Patterns of Mortality*, United Nations publication, Sales No.: 1955.XIII.9.

[9] These generalizations have been made for the purpose of population projections for individual countries, and model life tables have been arranged in a sequence representing expectations of life which may follow each other at time-intervals of 5 years. The last table in the sequence is one with an expectation of 73.9 years. See *Methods of Estimating Population. Manual III: Methods for Population Projections by Sex and Age*, United Nations publication, Sales No.: 1956.XIII.3.

[10] That the fertility of many populations has been fairly constant in the past can be verified in an examination of their age composition. Evidence that a gross reproduction rate of very nearly 3 prevails in many parts of the world can be deduced by the comparison of theoretical age structures with those actually observed in the Note, appendix A.

[11] There are no reliable records of past fertility trends in areas of previously very high mortality. Fertility must have been high enough to ensure population replacement in the face of recurrent catastrophic losses but, under adverse health conditions, could hardly have been much higher than currently observed.

[12] Age at marriage, frequency of marriage, practices affecting the average intervals between successive births, and health conditions are among the factors which prevent fertility from rising to the physiological maximum.

On the other hand, it must be conceded that in recent years no severe economic crisis with consequent mass unemployment has occurred. After the experience of the 1930s, the possibility cannot be discounted that, under adverse economic conditions, birth rates in Western countries may fall off sharply.

In view of the foregoing, population models incorporating current gross reproduction rates of 3, 1.5 and 1.25 appear to be the most relevant to the present purpose. Account must be taken also of past trends in fertility whose effects on current age structure will have further repercussions on future rates of population growth. In this context, gross reproduction rates as high as 2.25, and as low as 1, in the fairly recent past, are relevant for models of populations with currently moderate or low fertility.

This leaves Japan as the one area where the level at which fertility can stabilize remains undetermined. An unprecedented and sharp fall has brought the Japanese crude birth rate from 34.3 per 1,000 in 1947 to 20.1 per 1,000 in 1954, and the fall is still continuing. It is impossible to say whether, in the future, birth rates in Japan will tend to be either higher or lower than in 1956, the most recent year of observation, when the rate had declined to 18.5.

3. *Changes in fertility level*

While comparative stability of family building habits, as conditioned in each cultural context, appears to be the more normal situation, the phenomenal changes in contemporary economic and social organization have been, and will continue to be, accompanied by changes in reproductive behaviour.

One consideration, and perhaps the most important one in the long run, follows from the decline in mortality. Previously only about one-half of all new-born children survived to adulthood; now the babies' chances of living up to the ages where they, in turn, become parents surpasses 90 per cent among an ever-increasing segment of the world's population. The combination of a birth rate near 45 per 1,000 with a death rate near 10 per 1,000 has in recent years been reliably recorded in several countries[13], the corresponding rate of natural increase being 3 1/2 per cent per annum. At this rate, a population doubles in 20 years and increases ten-fold in 67 years, a rate of growth whose continuation over a very long time span is difficult to imagine.

For a shorter time period, such as 1950–1975, however, there appears to be no necessary relationship between levels of mortality and fertility. Observations have shown constant high fertility levels among populations of high, moderate, and even low mortality. Fertility declines have occurred in various populations at times when mortality was still high (e.g., in France some 150 years ago), but also after mortality had fallen to moderate or low levels. Nor can it definitely be stated that population growth at a very high rate over a comparatively short period, such as 25 years, cannot continue.

Where fertility declines have occurred or are in progress, the onset and speed of the decline appear to be conditioned by a complex set of economic, social and cultural circumstances. The exact conditions which accompany reductions in fertility remain, so far, quite incalculable. Once fertility has been low, subsequent rises to a slightly higher level have also been noted.

Owing to this wide area of uncertainty, it is necessary to employ for each situation at least two alternative models encompassing some of the more extreme trends of fertility which can reasonably be expected in the future. The alternatives of constant or declining fertility apply irrespective of whether mortality is high or low.

Populations of high fertility, with gross reproduction rates of the order of 3, differ between themselves mainly in respect of the current level of mortality, the level of fertility having been, in all cases, roughly constant in the past. In the absence of other criteria, it cannot be determined whether future fertility trends will be different where mortality is still high from those where mortality is already moderate.

A different problem arises in the case of populations of currently moderate or low fertility. In all these, current mortality is quite low, and fertility as well as mortality have declined at some time in the past. But there are considerable differences in the age structures of populations, depending on whether the fertility decline has occurred in the recent past or much earlier. These differences, in turn, affect the prospects of future population growth. Fertility has declined recently in Japan and the Soviet Union, and fairly recently in Temperate South America and Southern Europe. In Northern America, Northern, Western and Central Europe, and Australia and New Zealand, fertility has declined since the end of the last century, reaching a very low level in the 1930s, but with some subsequent recovery to the current levels. As a result, trends of growth differ among regions with currently moderate fertility (gross reproduction near 1.5) and either early or recent fertility decline, and among regions with currently low fertility (gross reproduction near 1.25) in some of which fertility has declined earlier than in others.

Some Governments in countries of high fertility are actively considering a policy designed to enable people to limit the number of births. In other countries, policies are in effect which aim at maintaining a birth rate at least sufficient for a continuous replacement of generations. There is no clear evidence at this time of the extent to which such policies are, or can be effective. Basic research in the physiology of reproduction may some day provide a measure of birth limitation suitable for widespread use; but it is not possible to speculate on the eventual effects of a discovery which has not yet been made. On the evidence of past records, future trends in fertility can be conceived only as a continuation of past trends,

[13] Among such countries are Ceylon, Costa Rica, Malaya, Singapore, Taiwan, and Venezuela.

whose considerable inertia has been demonstrated. Plausible future trends, therefore, have been formulated as follows :

(*a*) Where gross reproduction has hitherto been of the order of 3, it may remain constant, or it may decline either in the near or the remote future;

(*b*) Where current gross reproduction rates are of the order of 1.5, or 1.25, future rates, sooner or later, may tend towards 1.5, 1.25, or 1, in each case.

The second of these sets of future assumptions does not raise a major problem since the change in reproductivity involved is in no case very drastic. But, when fertility declines from an initially high level, very different results follow depending on whether the fall is rapid or slow. A basis for a prediction of the speed with which fertility can decline in particular areas is, of course, lacking, but some indications of possible trends may be derived from the past experience of Western populations.

The recent very sharp decline in the Japanese birth rate has been so extraordinary as to furnish no basis for reasonable prediction. Similar declines have occurred in several Western populations during periods of much greater length. Among these, the Netherlands population stands out in its slow though continuous decrease in the birth rate, from an average of 35.0 per 1,000 in 1880-1884 to 20.3 in 1935–1939, a period of 55 years. In Germany, on the other hand, the decline was quite rapid, from 32.9 in 1901-1910 to 20.3 in 1921–1930, i.e., within only 20 years. In both instances, the gross reproduction rate had decreased from about 2.25 to about 1.25, i.e., by one unit, but the average annual decrease in gross reproductivity was by 0.018 points in the Netherlands, and by 0.050 points in Germany. One may take an annual decline by 0.030 points in the gross reproduction rate as about the average of observed past trends for populations of declining fertility.

C. Theoretical population models

The current demographic situations of various world regions have been indicated in their roughest outline. They can be summarized under four types :

A. Constant high mortality, constant high fertility;
B. Declining mortality, constant high fertility;
C. Low mortality, fertility now moderate; and
D. Low mortality, fertility now low.

More sub-types will presently be distinguished (see p. 9-12). Each type describes a situation of the past, but future conditions in certain populations may resemble the past conditions of others. Models have been calculated showing the population changes which occur, under each set of conditions, in a 25-year period. Future population growth, to some extent, is an outcome of past trends because of their effects on age structure.

None of the models is expected to coincide exactly with the detailed conditions of any actual population. But they are intended to approximate sufficiently to the trends in regional populations to permit an inference regarding possible changes therein, subject to certain adjustments. The similarity of at least the recent trends suffices for this purpose, trends in the remote past having relatively small effect on the future. Concentration on the more recent past makes it possible to combine the several models in one relatively simple scheme.

The scheme was worked out, taking as an origin a population of type A, i.e., one in which conditions of fertility and mortality are assumed constant. A population of this type has special properties, and its composition by age groups and rate of growth can be calculated by appropriate mathematical methods.

Allowing for all necessary subsequent changes in levels of fertility and mortality, populations of all the remaining types could be calculated from this initial population by standard methods of population projection [14].

As applied to actual regional populations, the models serve as a first approximation of future rates of growth, by 5-year intervals of time, over each of two 25-year periods, namely 1950–1975, and 1975–2000. At each point, alternative future trends are considered in such a way that two series of estimates are obtained for the 1950–1975 period, and three series for the 1975–2000 period. The three latter series are identified as high, medium, and low, but the medium series follows in most instances upon the high series for 1950–1975, except for the population of one region, where the medium series is one of two alternative trends which, after 1975 follow upon the low series for 1950–1975.

In each instance, the projection is that of a model whose current age structure has resulted from past trends, the current date being taken as the year 1950. Depending on additional assumptions as to changes in mortality and fertility, future trends of growth are a logical further development of those of the past.

The schemes of population models which are intended to typify the effects of past, as well as future, trends of mortality and fertility are shown in the charts on the following pages. In these, the symbol ${}^{o}e_{o}$ stands for expectation of life at birth in years (both sexes combined), indicating the level of mortality, while GRR, the gross reproduction rate, indicates the level of fertility [15]. For brevity, the same symbols are also used in the text.

[14] The method consists in multiplying numbers within each age group (ages grouped by 5-year intervals) with age-specific survival ratios which are consistent with the mortality level of a period, to obtain numbers of survivors 5 years later when they are also 5 years older. Survivors to ages 0-4 are calculated from births occurring in the 5-year period according to age-specific fertility rates consistent with the fertility level of the period. In the present calculations, no distinction was made by sex. Otherwise, the methods are those described in *Methods of Estimating Population. Manual III : Methods for Population Projections by Sex and Age*, op. cit.

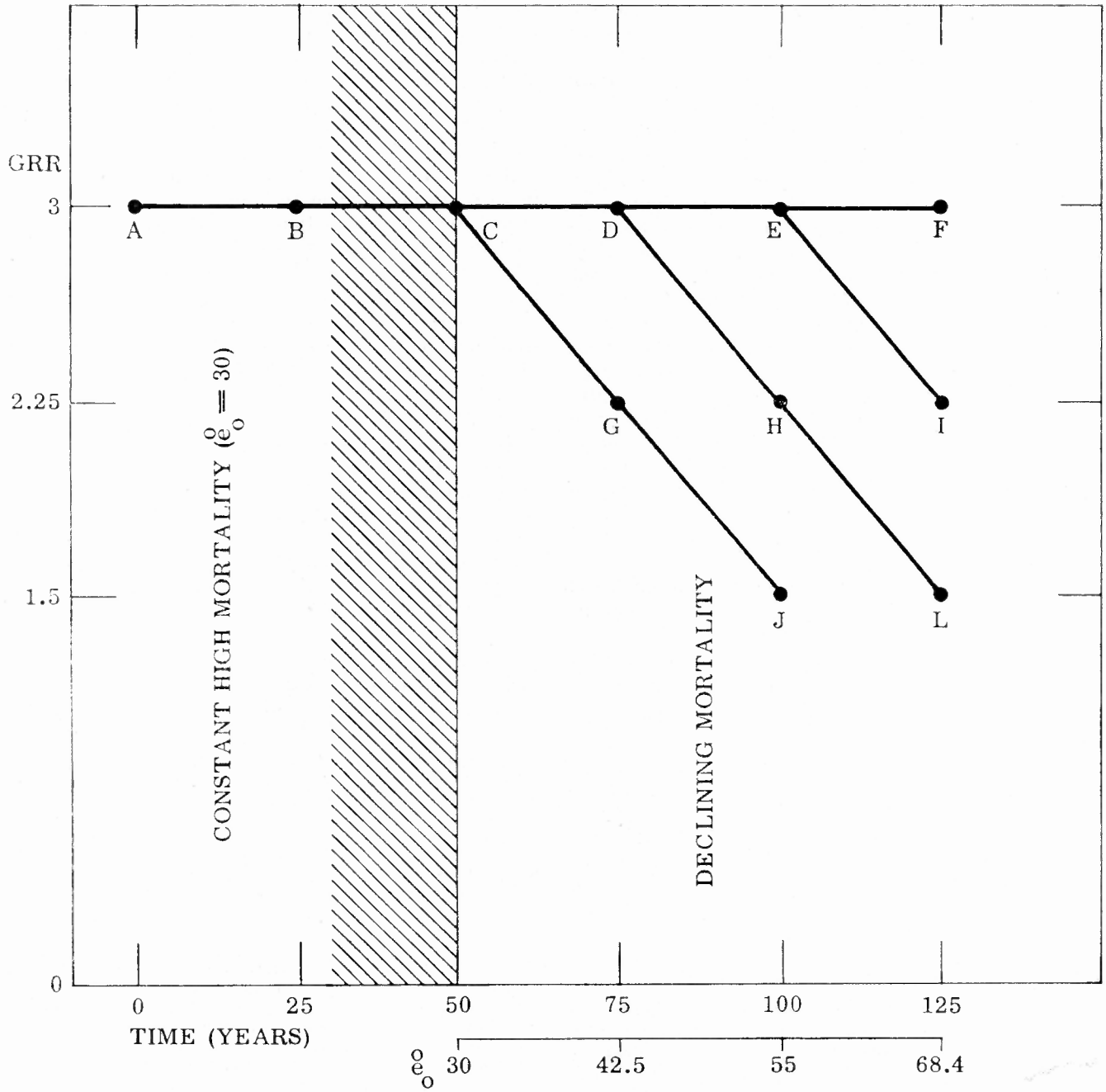
[15] As already indicated, age-specific rates of mortality are those of a model life table, with given ${}^{o}e_{o}$, representing the most typical combination of mortality conditions for the given general level of mortality. Similarly, for each level of fertility, as defined by GRR, a typical combination of age-specific fertility rates is assumed, the rates being applicable to numbers of the population of both sexes combined, to simplify the calculations. Though this is not a conventional method of defining the gross reproduction rate, the procedure does not introduce an appreciable error, at least for the present purposes.

Populations with hitherto high levels of fertility (chart II)

In chart II, the populations of type A and B are considered. The vertical axis of the chart indicates the level of fertility (GRR), while the horizontal axis represents time. Where mortality is declining, the assumption being a uniform rate of decline, the horizontal axis also shows the level of mortality (with continuous increases in $^{o}e_{0}$).

Populations of type A (constant high mortality, constant high fertility) are symbolized by the horizontal line in the left-hand upper corner. The model, constructed by the mathematical method, is one where GRR is constant at 3, and $^{o}e_{0}$ is constant at 30, it being supposed that these conditions have prevailed over an indefinite period of the past.

CHART II. MODELS FOR POPULATIONS WITH HITHERTO CONSTANT HIGH FERTILITY



It is assumed that these conditions are being approximated by the population of the Middle Africa region. Since it is uncertain whether mortality will decline significantly in the near, or even the more remote, future, conditions may essentially remain the same, at least on the low assumption. The corresponding projection is that from point *A* in 1950 to point *B* in 1975 and point *C* in 2000. The medium assumption is one where mortality will decline with considerable speed only from 1975 onward; on this assumption, the line *BC* is the projection for 1950–1975, and the line *CD* that for 1975–2000, $^{o}e_{o}$ rising eventually to 42.5. On the high assumption, it is supposed that decisive progress in mortality has already set in, $^{o}e_{o}$ rising to 42.5 by 1975, and to 55 by 2000, the projections for the two periods being represented by the lines *CD* and *DE*. This is the only population type for which future assumptions are varied with respect to mortality, rather than fertility.

For populations of type B (declining mortality, constant high fertility), three sub-types have been distinguished, according to the mortality level attained by 1950. In all three cases, GRR is taken to be of the order of 3.

For type B-1, which represents, in a rough approximation, the conditions in South-West Asia, Central South Asia, and East Asia (without Japan), it is assumed that $^{o}e_{o}$ in 1950 did not yet significantly surpass 30 while, as from that time onward, continued and considerable progress in mortality is the normal expectation. Accordingly, $^{o}e_{o}$ rises to 42.5 in 1975, and to 55 in 2000. The high assumption is one of continued high fertility, the projections being those corresponding to lines *CD* and *DE*. On the medium assumption, fertility is supposed to decline, through an annual decrement of 0.03 in GRR, from the year 1975 onward; here, the projection *CD* is followed by the projection *DH*. On the low assumption, fertility decline is assumed to have already started, and the projection is that of line *CG* in 1950–1975, and *GJ* in 1975–2000.

Type B-2, intended to resemble the conditions of Central America and Tropical South America, begins with point *D* in 1950, with $^{o}e_{o}$ equal to 42.5, rising to 55 in 1975 and 68.2 in 2000. Continued high fertility, the high assumption, results in projections *DE* for 1950–1975, and *EF* for 1975–2000. Fertility decline after 1975, the medium assumption, corresponds to the projection *EI* for 1975–2000. On the low assumption, where fertility decline is already in progress, the projections are *DH* for 1950–1975, and *HL* for 1975–2000. Though of constantly lower fertility, the population of the Caribbean has also been associated with this type, a separate adjustment in rates being made, as explained further on.

In Northern Africa and Southern Africa, current mortality levels are intermediate between those of types B-1 and B-2 above, and mortality is declining. The regions have been associated with a separate type, B-3, in which it is supposed that rates of population increase, in each 5-year period, are intermediate between those of types B-1 and B-2. No separate models were calculated for this type of population, but the rates of growth obtained, on each assumption, from the models of type B-1 and B-2 were averaged.

Populations with currently moderate fertility (chart III)

In all regions with currently low or moderate fertility, mortality is now quite low. For present purposes, little error is involved in assuming $^{o}e_{o}$ to equal 68.2 years in 1950. Continued progress would raise $^{o}e_{o}$ to 73.9 by 1970, but no very significant error is involved in considering $^{o}e_{o}$ constant from that point onward, though mortality is likely to decline somewhat further. Because, in the present projections, $^{o}e_{o}$ is maintained constant once it reaches 73.9, the horizontal time-scale of chart III ceases to be a scale of rising $^{o}e_{o}$ from that point onward.

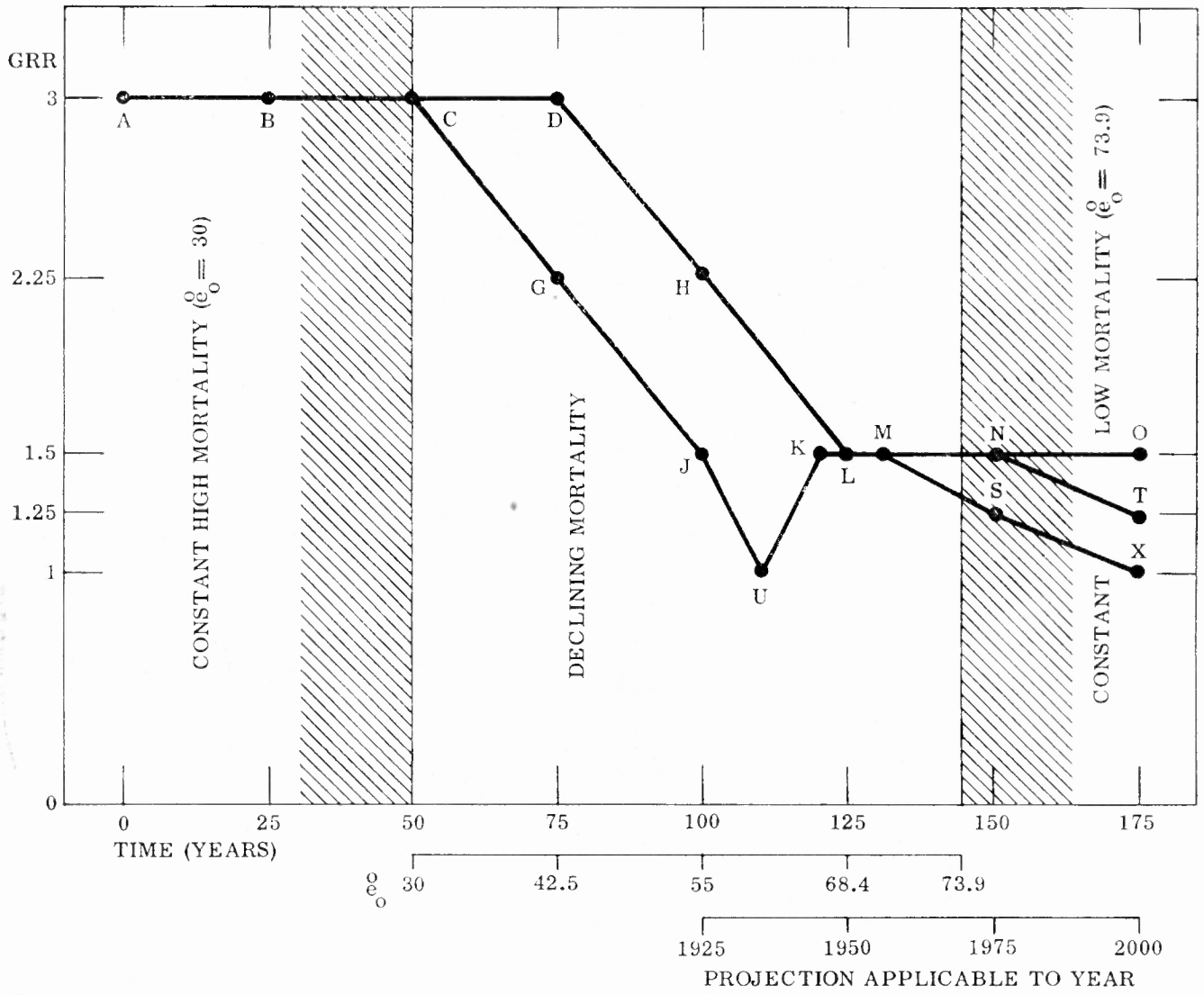
Decline of fertility from initially high levels has been considered as the low alternative for future projections of populations of type B. The same models can serve as past trends for populations in which, as a result of past declines, fertility is now either moderate or low.

Moderate fertility, with GRR equal to 1.5 in 1950, can have been attained either as a result of early or more recent decline. In other words, the point *L*, describing the position in 1950, may have been attained either from a point *H* or a point *J* in 1925. The distinction is important because of the resulting differences in current age structure. It is true that trends in the populations considered have been rather irregular in the past 25 or 50 years and not as smooth as described by the straight lines *GJ*, or *HL*, used for calculation of the models. Trends in the more remote past may have been entirely different from those of the models preceding points *G* and *H*. But for the present purpose, a very rough approximation of past trends can suffice. For populations in which fertility has declined in the earlier part of this century, it has been necessary to take into account the approximate trends in the 1925–1950 period, comprising a sharp depression of birth rates in the 1930s, followed by recovery, prior to 1950, to levels approximating those which prevailed around 1925. It is known, furthermore, that fertility has remained fairly constant in these populations during the past 10 years or so, hence the constant level determined by points *K* (for 1945) and *M* (for 1955).

Type C-1, defined by past trends *CG*, *GJ*, *JUKL*, and the current trend *LM*, is assimilated to the populations of Northern America, and Australia and New Zealand. Here, GRR is supposed to have fallen from 1.5 in 1925 to 1 in 1935, and to have risen to the current level of 1.5 by 1945. On the high assumption, it remains constant throughout (projections *LMN*, and *NO*), on the medium assumption, it declines from 1.5 in 1975 to 1.25 in 2000 (projection *NT)*, and on the low assumption it declines from 1.5 in 1955 to 1.25 in 1975, and to 1 in 2000 (projections *LMS*, and *SX*).

Type C-2, defined by the trend *HL* in 1925–1950, is taken to approximate current conditions in the Soviet Union. Future trends in fertility and mortality are assumed as under type C-1, but rates of growth will differ because of the different current age structure.

CHART III. MODELS FOR POPULATIONS WITH CURRENTLY MODERATE FERTILITY



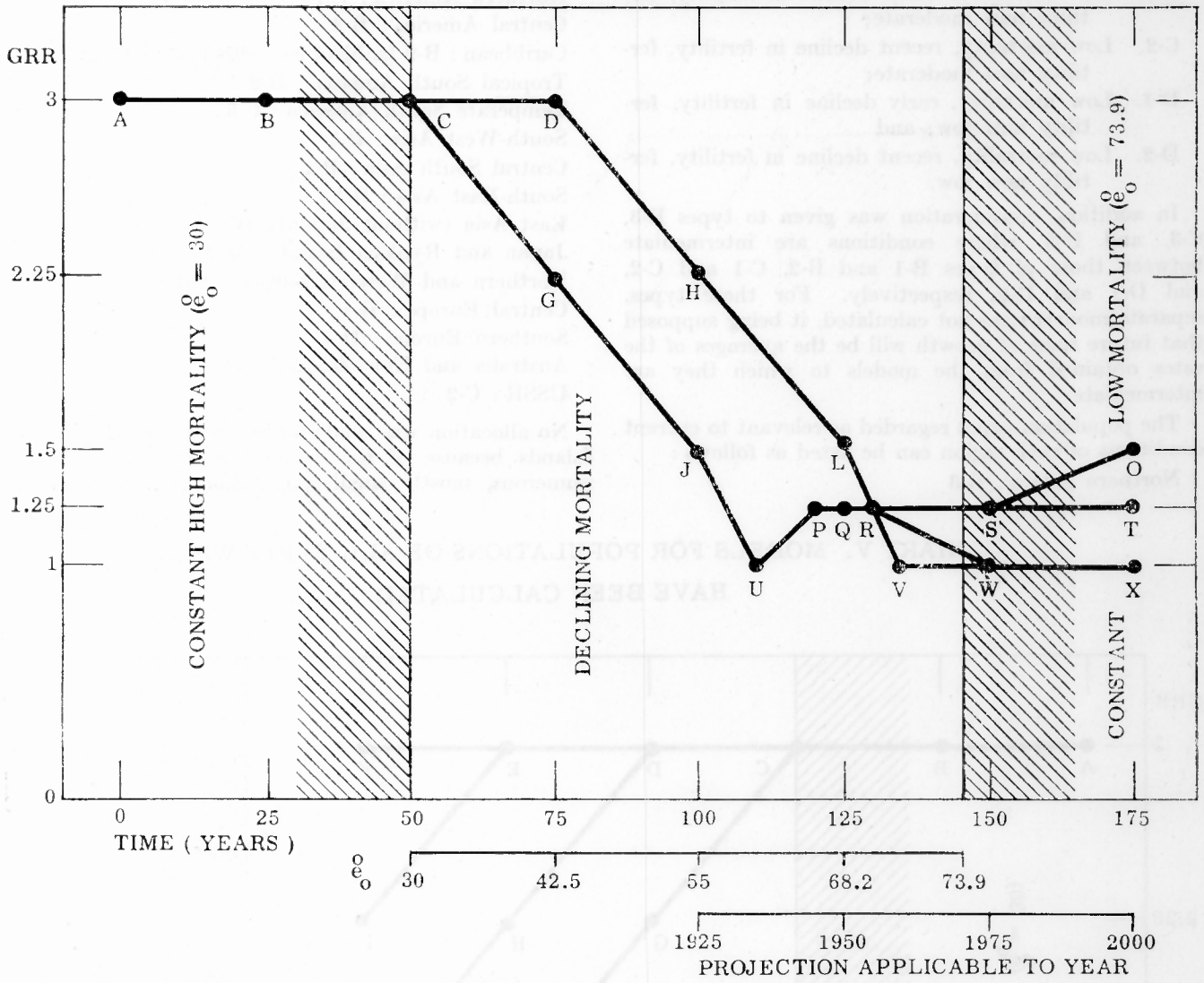
In Temperate South America, fertility has declined more recently than in populations of type C-1, but less recently than in the Soviet Union. This situation, defined as type C-3, is intermediate between types C-1 and C-2. No separate models have been calculated, it being supposed that, on all assumptions, future rates of population growth, in each 5-year period, will be the average of those resulting from the models for C-1 and C-2.

Populations with currently low fertility (chart IV)

Chart IV shows past and assumed future trends for populations in which GRR is currently of the order of 1.25. Again, the current level, represented by point *Q* for 1950, can have been attained as a result of different past trends, with different age structure of the population and different future rates of growth. As in the populations with current GRR of the order of 1.5, mortality is low, $^{o}e_0$ being around 68.2 in 1950, rising to 73.9 in 1970, and there is no need to project further mortality declines beyond that point.

Under type D-1, fertility has been declining since the beginning of the century, passing through a depression in the 1930s. But subsequent recovery to the level which has prevailed in the past ten years has been less pronounced than in populations of type C-1. Accordingly, GRR is taken as 1.5 in 1925 (point *J*), 1 in 1935 (point *U*), and 1.25 from *P* to *R* (1945–1955). On the high assumption, GRR remains at 1.25 until 1975 (point *S*) and then rises to 1.5 by 2000 (point *O*). On the medium assumption, it remains at 1.25 throughout (projections ***QRS***, and ***ST***). On the low assumption, it falls to 1 by 1975, and then remains at that level (lines ***QRW***, and ***WX***). The populations assimilated to this type are those of Northern and Western Europe, and of Central Europe.

CHART IV. MODELS FOR POPULATIONS WITH CURRENTLY LOW FERTILITY



The population of Japan, where fertility has declined recently, and very sharply in the most recent years, can be assimilated to type D-2. This type is defined by the trend from point *H* to point *L* in the 1925–1950 period, with a further fall of GRR from 1.5 to 1.25 from 1950 to 1955. Future fertility trends, on the high and medium assumptions, have been conceived in the same terms as for type D-1 (lines *LRS*, and *SO*, or *ST*, respectively). On the low assumption, the sharp downward trend continues until 1960, when GRR drops to 1, and remains at that level subsequently (lines *LRVW*, and *WX*).

Again an intermediate type, D-3, had to be considered, having regard to past trends in Southern Europe. Here, the fertility decline had preceded that of Japan and, though accentuated in the 1930s, has continued until quite recently. Current and future conditions, therefore, may very well be intermediate between those of types D-1 and D-2. No separate model has been calculated, it being supposed that, on all the assumptions, future rates of growth in each 5-year period will be the average of those resulting in models D-1 and D-2.

Summary (chart V)

Using very rough approximations, assimilation has been made of regional populations to populations of various types whose structures and rates of growth can be calculated in a coherent system of population models, account being taken both of past and possible future trends in mortality and fertility.

The detailed types for which the models have been worked out are the following :

A. Constant high mortality, constant high fertility;

B-1. Mortality very high but declining, hitherto constant fertility;

B-2. Mortality moderate and declining, hitherto constant fertility;

C-1. Low mortality, early decline in fertility, fertility now moderate;

C-2. Low mortality, recent decline in fertility, fertility now moderate;

D-1. Low mortality, early decline in fertility, fertility now low; and

D-2. Low mortality, recent decline in fertility, fertility now low.

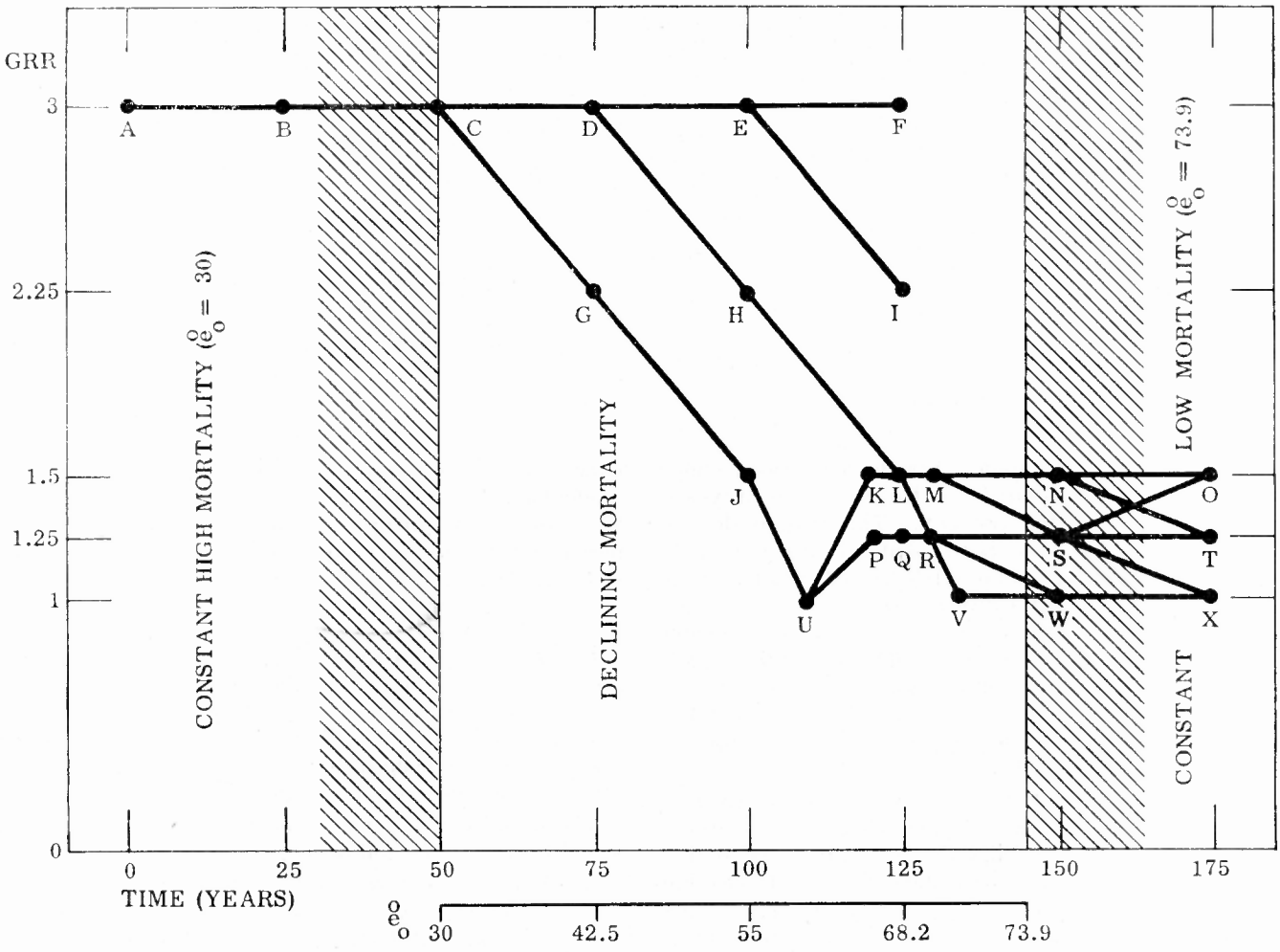
In addition, consideration was given to types B-3, C-3, and D-3, where conditions are intermediate between those of types B-1 and B-2, C-1 and C-2, and D-1 and D-2, respectively. For these types, separate models were not calculated, it being supposed that future rates of growth will be the averages of the rates obtained from the models to which they are intermediate.

The population types regarded as relevant to current conditions of each region can be listed as follows :

Northern Africa : B-3
Middle Africa : A
Southern Africa : B-3
Northern America : C-1
Central America : B-2
Caribbean : B-2 (subject to further adjustment)
Tropical South America : B-2
Temperate South America : C-3
South-West Asia : B-1
Central South Asia : B-1
South-East Asia : B-1
East Asia (without Japan) : B-1
Japan and Ryukyu Islands : D-2
Northern and Western Europe : D-1
Central Europe : D-1
Southern Europe : D-3
Australia and New Zealand : C-1
USSR : C-2

No allocation was made for the region of the Pacific Islands because of the extreme heterogeneity of its numerous, mostly small, populations; in view of its

CHART V. MODELS FOR POPULATIONS OF ALL TYPES WHICH HAVE BEEN CALCULATED



small importance, relative to world totals, little need was felt for a more detailed treatment of this region.

The complete scheme of model populations is shown in chart V. Past and alternative future trends of populations of each type are summarized below in terms of the lines on this chart. The maps that follow show the resulting past, current and possible future demographic conditions of world regions.

TABLE 3. PAST AND FUTURE TRENDS AND RATES OF GROWTH IN POPULATION MODELS CORRESPONDING TO POPULATIONS OF DIFFERENT TYPES, BY 25-YEAR PERIODS

Type	Assumption	Trends (as marked on Chart V)			Population increase within 25 years (per cent)		
		1925-1950	1950-1975	1975-2000	1925-1950	1950-1975	1975-2000
	high	(ABC) [a]	CD	DE	36.7	59.7	95.5
A	medium		BC	CD		36.7	59.7
	low		AB	BC		36.7	36.7
	high	(ABC) [a]	CD	DE	36.7	59.7	95.5
B-1	medium		CD	DH		59.7	77.8
	low		CG	GJ		45.7	43.2
	high	CD	DE	EF	59.7	95.5	129.9
B-2	medium		DE	EI		95.5	108.1
	low		DH	HL		77.8	66.5
	high	JUKL	LMN	NO	29.8	33.6	35.4
C-1	medium		LMN	NT		33.6	30.0
	low		LMS	SX		29.4	17.8
	high	HL	LMN	NO	66.5	53.3	43.4
C-2	medium		LMN	NT		53.3	37.7
	low		LMS	SX		48.2	25.2
	high	JUPQ	QRS	SO	25.3	21.6	21.8
D-1	medium		QRS	ST		21.6	17.1
	low		QRW	WX		17.7	5.6
	high	HL	LRS	SO	66.5	42.2	36.0
D-2	medium		LRS	ST		42.2	30.5
	low		LRVW	WX		33.6	13.6

[a] Stable population. Trends AB and BC are inherently the same.

D. ADJUSTMENT OF MODELS TO OBSERVED TRENDS

The models have been calculated in relative independence of the detailed statistics pertaining to each regional population. To make them conform more nearly to the facts, they require further adjustment [16]. Accordingly, a comparison was made between theoretical percentage increases of population in 1950–1955, according to the unadjusted models, and observed increases in regional populations, as obtained from the statistics presented in table 2. This comparison is presented in table 4, below.

Both sets of data are subject to error. Not all the available population estimates are very accurate, and regional rates of observed population increase may consequently be too high or too low. The models, on the other hand, are never fully appropriate as a representation of the precise conditions prevailing in each region. The discrepancies between observed and theoretical rates of increase, therefore, must be disposed of in a manner which tends to minimize errors from either source.

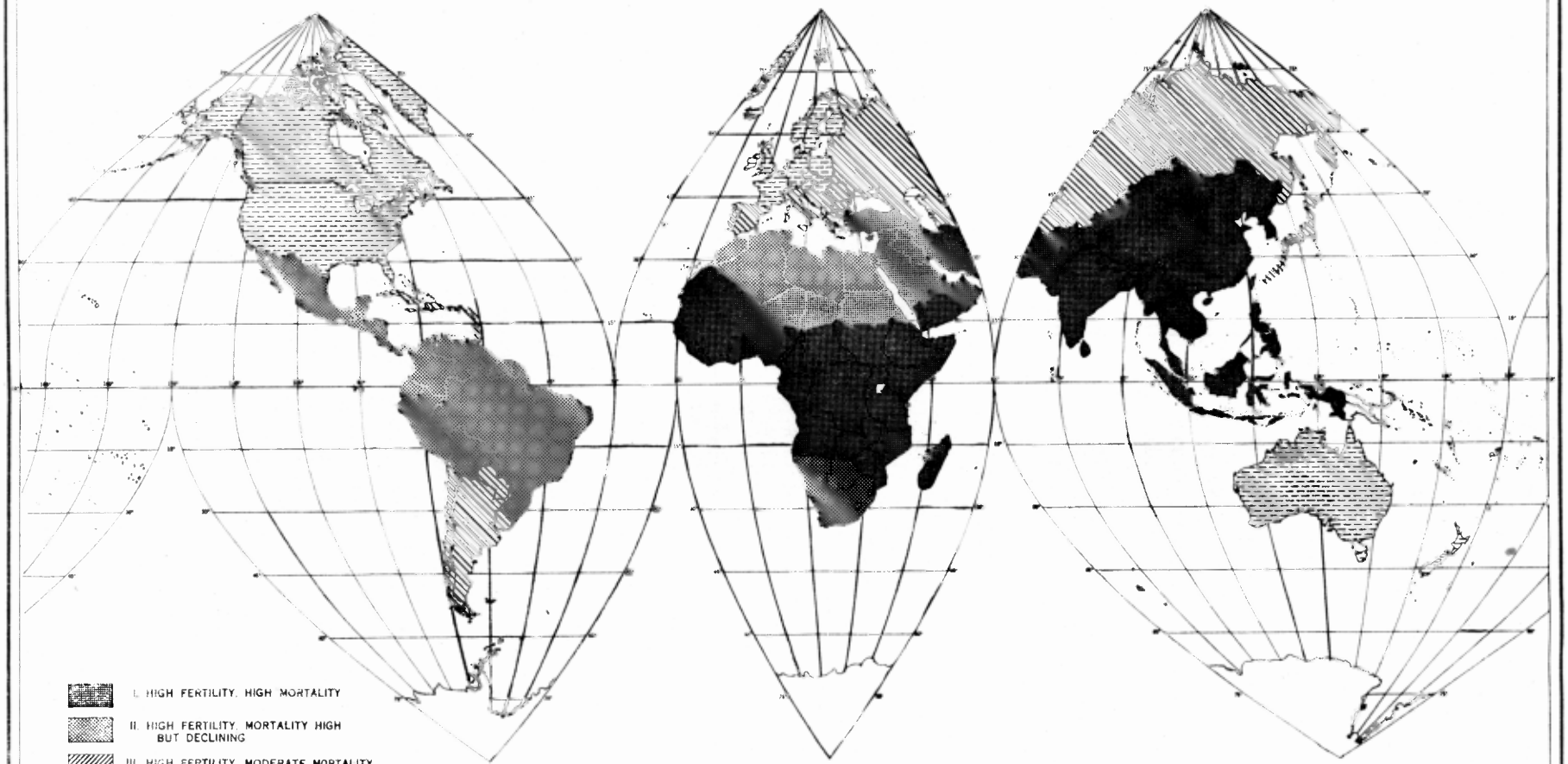
[16] A comparison of the theoretical birth rates, death rates and age structures of models with corresponding statistical observations is made in the Note on the adequacy of the models (p. 53 et seq.).

If models are to conform to observations of the 1950–1955 period, rates of increase in the models, for this period, must be adjusted by the full amount of the noted discrepancy. For future periods, the nature of the adjustment can vary, depending on the most plausible explanation of the nature of the discrepancy.

Discrepancies of less than one per cent in the rate of population growth over 5 years are rather small and require no detailed investigation. The eight regions in table 4 having such small discrepancies are: Central South Asia, East Asia (without Japan), Tropical South America, Northern Africa, Southern Africa, Central Europe, the USSR, and Japan & Ryukyu Islands.

Migration has not been introduced into the theoretical population models; where it has been of relative importance, it should account for some discrepancies. In addition to current migration, past migratory movements also affect population growth because of their influence on age structure. Immigration is known to have contributed to population growth particularly in Northern America, Temperate South America, and Australia & New Zealand; for all three regions, discrepancies in table 4 are positive. Emigration is known to have affected the populations of the Caribbean, Northern & Western Europe, and Southern

WORLD REGIONS BY TYPES OF DEMOGRAPHIC SITUATION, AROUND 1930



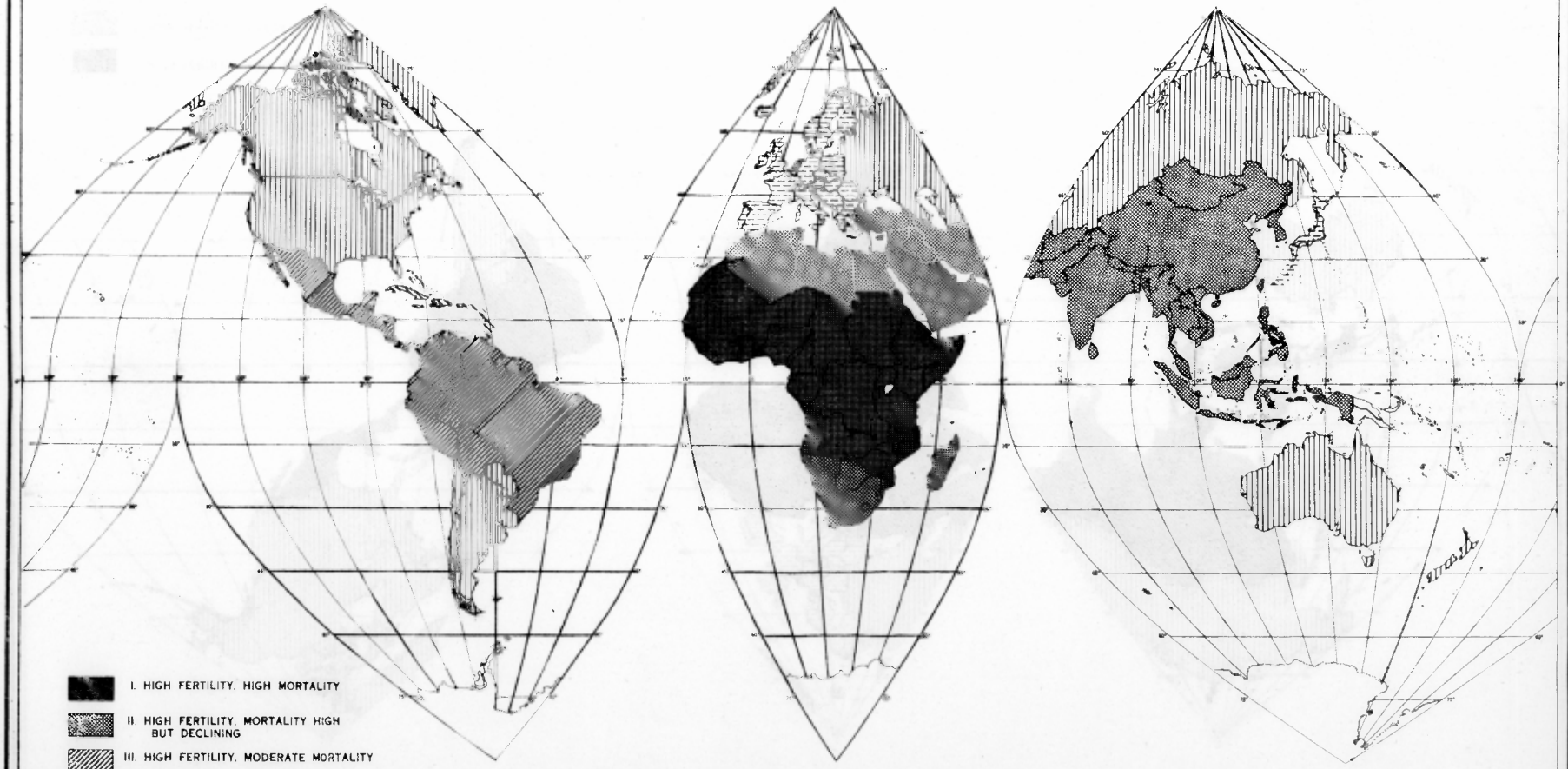
SINUSOIDAL EQUAL AREA PROJECTION

0 1000 2000 3000
MILES
0 1000 2000 3000
KILOMETRES

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 1000 UNITED NATIONS
JANUARY 1958

WORLD REGIONS BY TYPES OF DEMOGRAPHIC SITUATION, IN 1950 - 1955



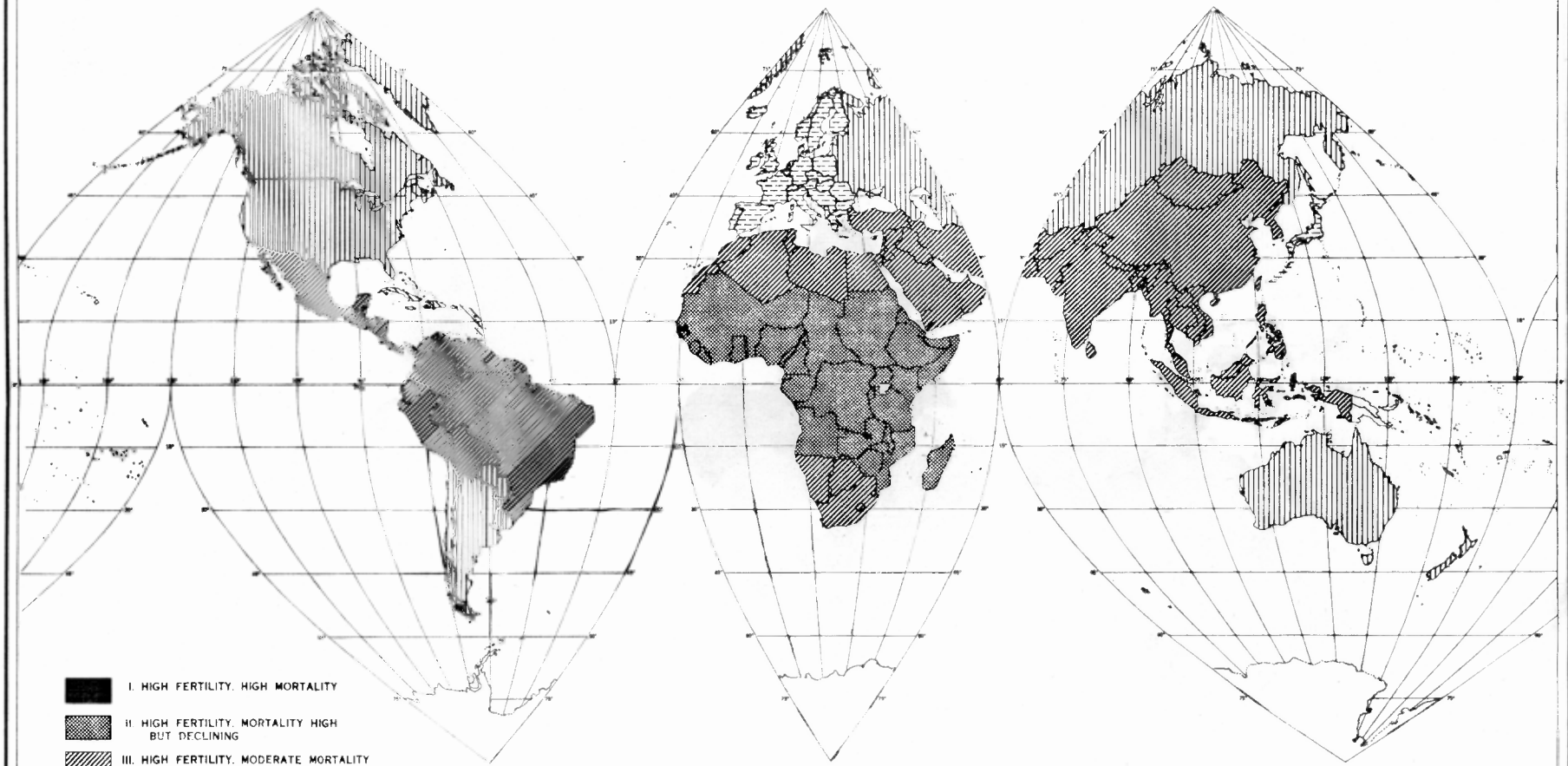
SINUSOIDAL EQUAL-AREA PROJECTION

0 1000 2000 3000
MILES
0 1000 2000 3000
KILOMETRES

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 1031
JANUARY 1958
UNITED NATIONS

WORLD REGIONS BY TYPES OF DEMOGRAPHIC SITUATION BY 1975, "HIGH" ASSUMPTIONS



SINUSOIDAL EQUAL-AREA PROJECTION

0 1000 2000 3000
MILES

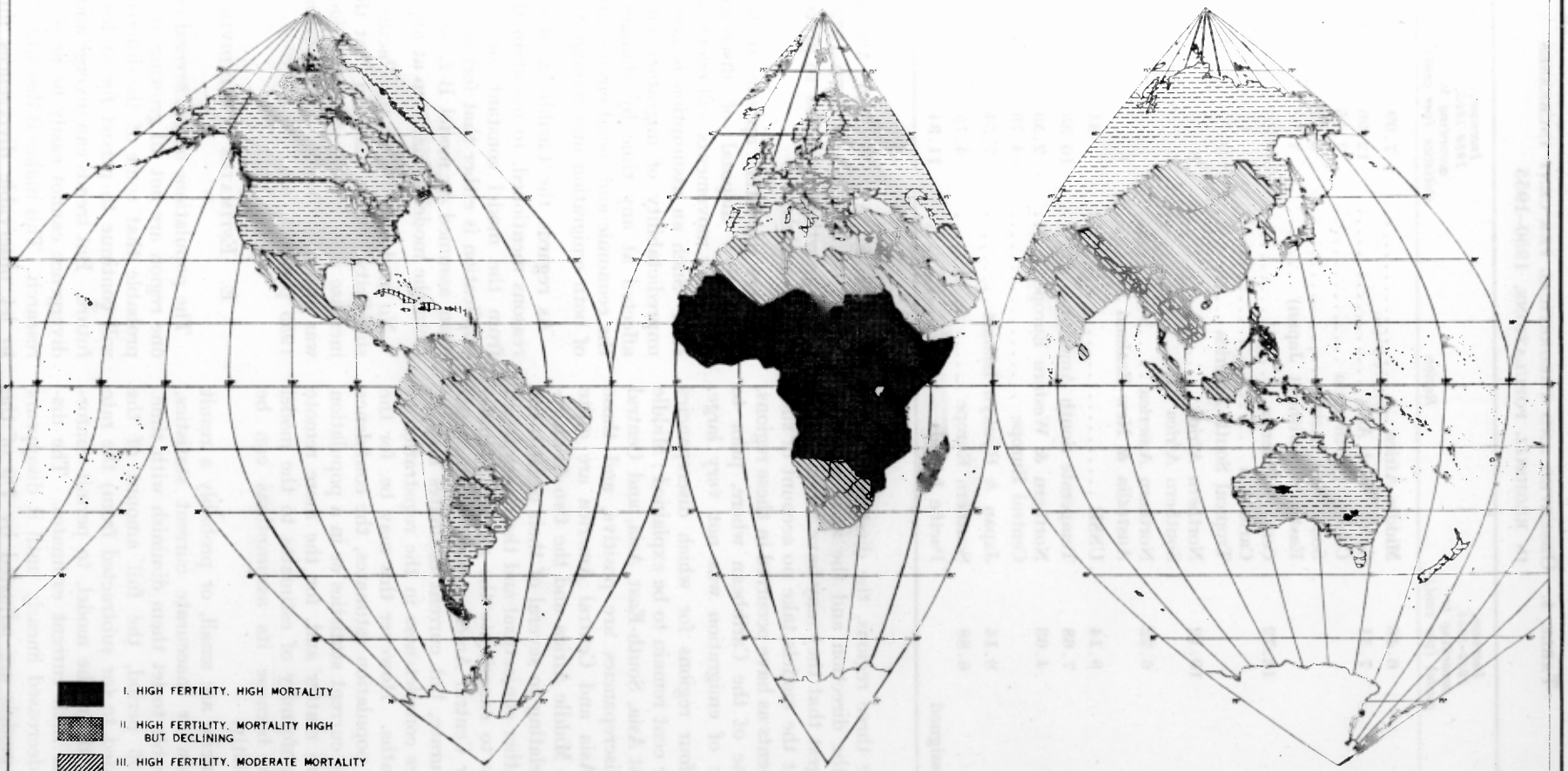
0 1000 2000 3000
KILOMETRES

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 1002
JANUARY 1958

UNITED NATIONS

WORLD REGIONS BY TYPES OF DEMOGRAPHIC SITUATION BY 1975, "LOW" ASSUMPTIONS



SINUSOIDAL EQUAL-AREA PROJECTION

0 1000 2000 3000
MILES

0 1000 2000 3000
KILOMETRES

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 1068
JANUARY 1958

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TABLE 4. OBSERVED AND THEORETICAL PER CENT INCREASES IN REGIONAL POPULATIONS, 1950–1955

Type	*Increase, 1950-1955, according to model (per cent)*	*Region*	*Increase, 1950-1955, according to statistics (per cent)*	*Discrepancy*
A	6.46	Middle Africa	7.99	+ 1.53
B-1	7.51	South-West Asia	12.96	+ 5.45
		Central South Asia	7.15	— 0.36
		South-East Asia	8.56	+ 1.05
		East Asia (without Japan)	7.83	+ 0.32
B-2	12.72	Central America	15.35	+ 2.83
		Caribbean	9.05	— 3.67
		Tropical South America	12.15	— 0.57
B-3	10.12	Northern Africa	10.54	+ 0.42
		Southern Africa	9.78	— 0.34
C-1	6.22	Northern America	8.84	+ 2.62
		Australia & New Zealand	12.27	+ 6.05
C-2	9.14	USSR	8.84	— 0.30
C-3	7.68	Temperate South America	10.33	+ 2.65
D-1	4.63	Northern & Western Europe	2.59	— 2.04
		Central Europe	4.79	+ 0.16
D-2	8.14	Japan & Ryukyu Islands	7.54	— 0.60
D-3	6.88	Southern Europe	4.75	— 2.13
Unassigned		Pacific Islands	11.34	...

Europe; for these three regions, the discrepancies are negative. Both the direction and the amount of the discrepancies suggest that they may have arisen largely from the fact that the models take no account of such migratory movements as have occurred in these regions, except in the case of the Caribbean where, prior to 1950, the volume of emigration was not very large.

There remain four regions for which discrepancies greater than 1 per cent remain to be explained : Middle Africa, South-West Asia, South-East Asia, and Central America. The discrepancies are positive, and those for South-West Asia and Central America are quite large. As regards Middle Africa and the two Asian regions, estimates relating to several of their constituent populations are rather conjectural and there may be an inherent tendency to exaggerate the rates of population growth. For Central America, population statistics are more accurate, but current estimates may be affected by greater completeness in the registration of births than of deaths. However this may be, for the purpose of future population estimates, the confidence to be placed in the current statistics or in a population model is a relative matter and, for the more remote future at least, conformity of estimates to the model is more desirable because its assumptions can be stated more explicitly.

Where discrepancies are small, or probably a result of either migration or inaccurate current statistics, it appeared preferable to let them diminish with time. For the 1950–1955 period, the full amount of the discrepancy is added to (or subtracted from) the rate of population growth in the model, to permit conformity of the model with current estimates. The discrepancy is then decreased linearly until it disappears in 1975, so that models are adjusted by 7/9 of the discrepancy in 1955–1960, 5/9 in 1960–1965, 3/9 in 1965–1970, and 1/9 in 1970–1975. After 1975, population growth is supposed to proceed exactly according to the models.

Where migration appears to be a factor, the same progressive disposal of discrepancies implies that migratory movements will eventually come to a standstill. Such an assumption is necessary in view of the unpredictability of migratory currents which can be affected at any time by changes in legislation or in the economic and social circumstances in the countries of both emigration and immigration.

As regards the Caribbean, it was decided, for the reasons mentioned, to maintain the noted discrepancy from the model constant for all future time. The implication is either that fertility is permanently lower than assumed in model B-2, or that the discrepancy from the model is made up at any time by emigration.

No model applies to the Pacific Islands region. For simplicity, it was assumed that this population would increase in all future 5-year periods at the rate which was observed (though largely estimated) for the 1950–1955 period.

E. ESTIMATES FOR INDIVIDUAL COUNTRIES

The populations of the several countries constituting one region are not all growing at the same rate. It is probable that some of the differences in growth rates will continue to persist for at least some time in the future. But trends can diverge and the degree of future divergence cannot easily be predicted without detailed research. This makes it desirable, for present purposes, to let observable divergences diminish gradually in

the future. In this manner, future estimates for all countries can be made which are at least not patently absurd.

A method of decreasing differences in rates of growth cannot, however, be applied to sub-totals if the sum of estimated future sub-totals is to agree with the estimated future total. Furthermore, the country estimates made here are regarded as mere by-products of the primary operation, which is to estimate the future total populations of each region.

Accordingly, a simple method has been resorted to, which is known as the ratio method. The rate of change in the ratio of a sub-total to a total is noted and projected to derive future sub-totals from the estimated future totals. Its use for the present purpose has been as follows. Both for 1950 and 1955, it has been determined what percentage of a regional population is contained in each particular country, and the change in the percentage, over the 5-year period, has been noted. It was then assumed that the change would continue, though at a diminishing rate, until it ceased after 1975. Thus, the given percentage, which has changed by a given amount in 1950–1955, would change by 7/9 that amount in 1955–1960, 5/9 in 1960–1965, 3/9 in 1965–1970, and 1/9 in 1970–1975. After 1975, the population of each country is assumed to increase at the same rate as the population of the region.

The ratio method, while useful, can lead to absurd results, if applied too mechanically. Clearly implausible results have been successfully avoided both by letting rates of population growth gradually converge with time, and by arbitrarily maintaining constant the figures for countries whose population in 1955 did not exceed 10,000.

An additional safeguard was used for a few countries where unusual events or an unusual volume of migration, unlikely to continue, had resulted in abnormal population changes during 1950–1955. Here, the calculation was made to depend on a fictitious population figure for 1950 such that, had conditions been normal, the population estimated for 1955 could have resulted from it.

F. The results and their limitations

Results are presented in the appendix tables. To avoid an undue impression of accuracy, all figures greater than one million have been rounded to three significant digits. Smaller figures have been rounded to the nearest thousand.

In appraising the value of these results it is necessary, first of all, to recognize that they have been obtained by methods of demographic projection. In other words, it has been assumed that future population growth will be the outcome of an orderly development of past and current trends in mortality and fertility. The record of the past shows that, in modern times, and for large populations, this has generally been the case. Wars, famines, epidemics and economic depression have caused various disturbances of trends but their effects, for the most part, have been quite transitory. Should conditions in the future prevent a logical continuation of past population trends, projections made with demographic methods will not be relevant. It is not particularly likely that this will happen in a majority of world regions. At least part of the projections made here, therefore, will retain some relative validity.

Aside from this matter of general principle, the value of the detailed figures remains to be considered. All future estimates are affected by errors in current estimates, in the estimated current trend, and in assumed future changes therein. Some of these errors affect the short run and others the long run. Relative errors are greater for some of the smaller figures and sub-totals than for the sums which have been compounded of several separate estimates.

The estimates for individual countries, a mere by-product of the general procedure, have been made chiefly with the purpose of facilitating a re-grouping of regional totals, if regional limits are to be redefined. Errors in these estimates, while relatively slight in relation to re-grouped regional totals, can be relatively quite large in themselves. Future population estimates for individual countries which have been arrived at separately by more detailed procedures should invariably be preferred. Where these are not available, the country estimates presented here may be useful for a limited period of the future, say up to 1965. Those for countries containing a substantial proportion of a regional population are likely to be more significant than those for small countries. Little value should be attached to the estimates for countries whose characteristics differ markedly from those of the greater part of the region.

Because of the indirect manner in which the country estimates were derived, it is impossible to specify the precise conditions under which the estimated populations are likely to be realized in actual fact.

As regards the regional estimates care has been taken to make them as realistic as available statistics and the simplified calculating scheme permit. Errors are probably involved in each step of the procedure. Those arising from inaccurate current population estimates affect future estimates mainly in the short run. Errors in the estimated current rates of population growth, caused by comparing estimates for 1950 and 1955 which are not strictly comparable, have cumulative effects on estimates for a more distant future [17]. Future changes in rates of growth depend on explicit assumptions, which have been made on the basis of plausible interpretation of demographic situations. But expectations which now seem plausible can be upset in the future as new events and improved observations affect the picture. Even then,

[17] Since censuses in many countries are taken at intervals of ten years, the estimates of a 5-year period suffer in comparability from the fact that one of the estimates is nearer the date of a census than the other. Prior to 1950, on the other hand, war-time and post-war conditions had temporarily interfered with population trends. A substantial improvement on the future estimates prepared here may become possible in a few years when the 1950–1960 period can serve as a basis for the calculations, it being assumed that many censuses will be taken in and around 1960.

the departure from present expectations can be described in terms of the assumptions formulated now.

For given regions, the emergence of new, not yet recognizable, trends cannot be predicted. But for the world as a whole it is highly probable that, in the course of time, unexpected developments will set in, first in one region, then in another, and so forth. The possibility of world-wide disasters, though always present, must be discounted here since it provides no rational basis for planning for the future. But, barring such cataclysmic events, those interferences with orderly population trends which arise in particular regions will probably not occur everywhere at the same time, nor will they invariably affect population growth in either a positive or a negative sense, relative to the assumptions made here.

It remains to be considered whether the scheme of assumptions, taken as a whole, is not biased in one direction. Speaking very broadly, assumptions differ in respect of populations with hitherto high fertility and populations with currently moderate or low fertility. High-fertility populations already form a majority of the world's population. Whether, or how much, their share in the world total will increase cannot be inferred with certainty from the present projections, since it is possible that assumedly high trends in populations of one type will coexist with assumedly low trends in populations of the other type. This possibility must not be left out of account since the high-fertility populations, on the whole, are those of the technologically under-developed countries; and economic progress in developed and in under-developed countries may proceed with divergent trends, in a manner which either reduces or reinforces the dichotomy already noted.

The total world population of the remote future is determined chiefly by populations of hitherto high fertility, since these already constitute the majority. As regards these, it has been generally assumed that:

1. Mortality will continue to decline at rates which now are normal; and
2. Fertility will: (*a*) remain constant until the year 2000 (high assumption), (*b*) decline at rates observed previously in some areas after 1975 (medium assumption), or (*c*) decline forthwith, and continuously until 2000, at such rates (low assumption).

To assume a continued mortality decline at this now normal tempo does not necessarily bias future estimates of world population. In certain areas and at certain times, the tempo will be either faster or slower, without substantially affecting average trends throughout the world. The basic assumption is that the social conditions prerequisite to progress in public health will be no worse in the future than they are at the present time.

Where fertility is high, declines are possible but appear to be hardly imminent. Small, at least temporary, increases have even been noted in connexion with improvements in public health, while small, at least temporary, decreases may be associated with rises in the average ages at which marriage is contracted. There is little evidence among populations of presently high fertility of those attitudes which, in Western countries and in Japan, seem to have been most closely associated with a deliberate control of family size.

Decreases in fertility may, and perhaps will, occur in various parts of the world at different times. It is quite improbable that they will occur simultaneously from 1975 onward in all areas of presently high birth rates. But in view of the length of the period and the intensity with which, apparently, population pressure is already being felt in some areas, it is rather probable that fertility decline will occur in at least certain regions before the year 2000.

The most probable estimates of future world population for the year 1975, therefore, would seem to fall slightly short of the high estimates and for the year 2000 to lie anywhere in the range between the high and medium estimates. It can therefore be stated that, barring either a catastrophe, or a deterioration of social conditions for progress in health, of global proportions, a world population of between 6,000 and 7,000 million by the end of the century should now be expected almost as a matter of practical certainty

Chapter II

THE RESULTS : TOTAL POPULATION

Total population, calculated from models adjusted to accord with observed facts, is shown in the tables of appendix C. Table I presents estimates, according to high, medium and low assumptions, for the world, continents and regions, for all dates, spaced by 5-yearly intervals, from 1950 to 2000. Table II shows the derived estimates for individual countries, on the medium assumption, from 1955 to 1975. The latter estimates, of lower reliability, are presented chiefly to facilitate the compilation of regional totals where countries are grouped differently than in the regions as defined here. Some of the long-range implications of the estimated figures of total population are discussed below.

A. The twentieth century, a unique phase in human history

Never in the history of mankind have numbers of the human species multiplied as rapidly as in the present century, nor can it be easily conceived that the peopling of the earth will continue at a similar pace in the century which follows. The present era is unique in that a predominance of man in the earthly environment is being established such as has never existed before.

In the hundreds of thousands of years since man's first appearance on this planet, some intermittent phases of expansion must have alternated with long periods of stagnation and numerous reversals. A new phase of growth, attaining numbers never reached before and surpassing them, has been gathering momentum in the past 200 or 300 years. In 1860, when there were about 1,250 million human beings they were already twice and perhaps three times as numerous as at any time previously.

Only 90 years have passed but they have brought the addition of another 1,250 million, which makes an estimated world population in 1950 of 2,500 million. A further 1,250 million will almost certainly be added in the 25-year period from 1950 to 1975. From 1975 to 2000, the additional increase will be by 1,250 million on the very improbable low assumption, by 2,500 million on the more plausible medium assumption, and perhaps even by 3,000 million on the high assumption.

Acceleration in the absolute amounts of increase is inherent in growth itself. And, in addition, the relative rate of world population growth is still in its ascending phase.

Estimated at 1,094 million in 1850, and at 1,550 million in 1900, world population grew in the latter part of the last century by 42 per cent in 50 years, or by an average of 19 per cent in each 25-year period. Rising to 1,907 million in 1925, and to 2,500 million in 1950, it has increased by 23 per cent, and then by 31 per cent in the two quarter-centuries of the 1900s.

For the remainder of our century, expectations differ according to specific assumptions. Only on the improbable low assumption, with increases by 44 per cent in 1950–1975, and by 36 per cent in 1975–2000, would there be some slow-down in the rate of world population growth before the end of the century. On the medium assumption, which implies some change in trends after 1975, the increases would be by 53 per cent in 1950–1975, and by 64 per cent in 1975–2000. On the high assumption, they would be by 54 per cent, and then by 79 per cent.

It would be absurd, at this time, to carry detailed calculations forward into a more remote future. It is difficult to imagine the conditions in a world inhabited by more than double the number of people now in existence. And it is most debatable whether the trends in mortality and fertility can continue much longer with the degree of inertia which has characterized them in the past. Factors other than the slow secular changes in fertility and mortality may eventually bring population growth to a halt. Otherwise, even if it is conceded that population growth, after its peak near the end of our century, might diminish gradually and cease within another century, world population would not stop growing until it had reached between 10,000 and 25,000 million. One cannot say that such further growth is utterly impossible, but the vast changes in human organization required to sustain it can hardly be conceived at the present time.

B. The question of the world's carrying capacity

Consideration of such numbers immediately raises the problem of determining at what point the earth would reach its maximum carrying capacity. Despite many attempts to find an answer to this question, the problem cannot be solved by scientific reasoning. Because of his powers of reflection man adapts himself to ever changing circumstances, and his eventual adjustment to a new situation cannot be predicted before that situation has arisen. Different technical and organizational responses to a given environment, evidently, will permit different numbers of human beings to exist on earth.

Couched in more conditional terms, the question can be formulated as follows: given the present store of knowledge and organizational techniques, and assuming them to be applied to an extent which is consistent with human endurance, what is the maximum number of individuals who can draw their sustenance from the earth's resources? The frailty of human nature and the rigidity of social structures impose limits on the most effective uses of known methods, and practical achievement always falls short of what would seem technically feasible. Therefore the question, even if made contingent on specific conditions, cannot be answered independently of some subjective appraisal of human powers. Some of the more serious answers to this question, subject to particular assumptions made in each instance, have resulted in figures varying from 5,000 to 16,000 million [1].

In view of current scientific progress, conditional estimates of the world's population-carrying capacity may now have to be revised upward. Recently our attention has been drawn to vast unused resources of vegetable substance in the sea, the possible uses of solar energy, and the likelihood that atomic energy will become widely available as a source of power in the near future. Other scientific discoveries may yet yield surprising results in terms of a more intensive use of the gifts of nature. But it is doubtful whether the limit to human numbers depends on technological progress alone.

Elaborate techniques in the intensive utilization of resources depend to an ever-increasing extent on a specialization of human activities which can be accomplished only by virtue of a high degree of social organization. This, in turn, requires individual discipline and restraint; things which human beings can scarcely tolerate beyond a certain point. A major disruption of the social fabric can nullify many of the gains which scientific progress has rendered technically feasible. It is questionable whether previous conditional estimates of the world's capacity can now be adjusted upward. If at all, by how much?

More disturbing than the projected figure of a population amounting to 6,000 or 7,000 million is the fact that it will probably be attained so soon. At the time of writing, the year 2000 is no further in the future than the year 1914 is in the past. Not only technical achievement but progress in international co-operation and organization will have to be more effective than during the past 43 years if the expected numbers of mankind are to be organizationally and technologically accommodated to the minimum conditions required for human dignity.

The wide disparity among current living conditions in different parts of the world, to a large degree renders illusory the considerations relating to the world as a whole. Objective conditions and subjective awareness of them, in particular areas, give rise to local and regional problems of population pressure whose effects are scarcely felt in other parts of the world. Recognizable problems, at least so far, are confined largely to their regional contexts.

C. Technologically developed and under-developed areas

A dichotomy now widely recognized is the division of the world into regions where intensive use is made of new technological methods, and others where this is not done to any comparable extent. Industrialization, urbanization, comparatively high incomes, and high degrees of literacy are some of the seemingly inevitable concomitants of technological development. Low mortality and low or moderate fertility likewise prevail in the developed areas, but are rare elsewhere. These various features are correlated in varying degrees, and a precise dividing line between developed and under-developed areas cannot be drawn. It has been generally agreed, however, that world regions can be classified in two categories, as follows:

1. *Technologically developed areas:* Northern America, Temperate South America, Japan, the three regions of Europe, Australia and New Zealand, and the USSR;

2. *Technologically under-developed areas:* The three regions of Africa, Central America, the Caribbean, Tropical South America, the four Asian regions other than Japan, and the Pacific Islands.

Out of a world total of 2,500 million in 1950, the population in regions of group 1 amounted to 863 million, i.e., 34.5 per cent; the remaining 65.5 per cent were in the under-developed regions of group 2. It appears almost inevitable that the proportion of world population in the under-developed regions will increase.

One indication of this is obtained if we consider the projections made on the medium assumptions for each region.[2] In 1975, there would be 1,170 million people inhabiting the regions of group 1, and 2,660 million inhabiting the regions of group 2; in a world total of 3,830 million, the proportions would be 30.5 per cent and 69.5 per cent respectively. By 2000, with 1,490 million in group 1 and 4,790 million in group 2, the proportions would become 23.7 per cent, and 76.3 per cent respectively.

There is room for doubt whether comparable assumptions will materialize in regions of both types. As already noted, current population trends in each of the two groups of regions are different, making it doubtful whether the future medium assumptions, drawn up in the two cases, are truly comparable. Furthermore, the economic and social problems in the two areas differ in kind, and it is possible that progress in one group of regions will be rapid while it is slow in the other group. For this reason, it is

[1] *The Determinants and Consequences of Population Trends*, United Nations publication, Sales No.: 1953.XIII.3. The studies on this particular subject, referred to in *The Determinants and Consequences of Population Trends*, have been published prior to 1946.

[2] Medium assumptions, up to 1975, coincide with high assumptions for all regions except Middle Africa, where they coincide with low assumptions. After 1975, medium assumptions differ from both high and low assumptions for all regions except that of the Pacific Islands, for which separate assumptions have not been made.

of interest to examine some of the extreme combinations of estimates which have been obtained separately for regions of either group.

If future population growth in regions of the first group were to conform to high assumptions while in those of the second group it were to correspond to low assumptions, in group 1 there would be 1,170 million people in 1975 and 1,550 in 2000; in group 2, there would be 2,690 million in 1975, and 3,590 million in 2000. The share in world population of developed regions would fall even with this extreme combination of assumptions, to 32.1 per cent in 1975, and to 30.2 per cent in 2000, while the comparative population of under-developed regions would rise to 67.9 per cent and, eventually, to 69.8 per cent.

There is equally good reason to consider the opposite extreme, where population growth in group 1 would come near the low assumption and populations in group 2 would increase in conformity with high assumptions. The populations of group 1 would then amount to 1,120 million in 1975 and 1,290 million in 2000, and those of group 2 to 2,690 million in 1975, and to 5,350 million in 2000. The share in world population of developed areas would fall to 29.4 per cent in 1975 and to 19.4 per cent in 2000, while the share of underdeveloped regions would rise to 70.6 per cent and finally to 80.6 per cent.

To sum up, the technologically advanced areas contain now slightly more than one-third of the world population. This share, according to the seemingly most plausible expectations, will drop to less than one-quarter by the end of the century. Under extreme assumptions, before this century is ended, it may fall to only slightly below one-third, but it may also dwindle to one-fifth.

Relative economic conditions in different parts of the world will change. The gulf in living conditions, separating the two groups of regions may be reduced, but it may also widen. One of the factors which militate against a narrowing of this gap is the expected rapid growth of population in areas whose technological equipment is still deficient. Incomes there are low, and a considerable part of the portion of these incomes that might be saved is continuously absorbed in the maintenance of a constant level of living for a growing population. The problem involved in raising the capital needed for technological improvements is likely to persist for a long time to come.

D. The population of continents, 1900–2000

Though not relevant to every social consideration, the traditional geographic division of the world by continents still holds the imagination. The continental totals derived from our regional projections, furthermore, are probably more reliable than the regional estimates considered separately. Estimates and projections of continental populations, accordingly, are summarized in table 5, below. The projections are those conforming to medium assumptions and are subject to the interpretations given at the end of the preceding chapter.

Table 5. Estimated population, and population projected by the medium assumption (in millions), of continents and the world, 1900, 1925, 1950, 1975 and 2000

Year	*World* [a]	*Africa*	*Northern America* [b]	*Latin America* [c]	*Asia* [d]	*Europe, incl. USSR*	*Oceania*
1900	1 550	120	81	63	857	423	6
1925	1 907	147	126	99	1 020	505	10
1950	2 497	199	168	163	1 380	574	13
1975	3 828	303	240	303	2 210	751	21
2000	6 267	517	312	592	3 870	947	29

[a] Sum of figures rounded to the nearest million.
[b] i.e., America north of Mexico.
[c] i.e., America south of the United States.
[d] Excluding the Asiatic part of the USSR.

The projections show that, as in the past, the populations of the continents will also increase at different rates in the future. Increases by quarter-centuries, and the proportion of world population contained in each continent at different dates, are shown in tables 6 and 7 below.

Table 6. Estimated percentage population increases per quarter-century in each continent and in the world, 1900–2000: medium assumptions for 1950–2000

Period	*World*	*Africa*	*Northern America* [a]	*Latin America* [b]	*Asia* [c]	*Europe, incl. USSR*	*Oceania*
1900–1925	23	22	56	57	19	19	57
1925–1950	31	35	33	65	35	14	36
1950–1975	53	52	43	86	60	31	59
1975–2000	64	71	30	95	75	26	40

TABLE 7. PERCENTAGE OF WORLD POPULATION CONTAINED IN EACH CONTINENT, ACCORDING TO ESTIMATES FOR 1900, 1925 AND 1950; AND PROJECTIONS ON THE MEDIUM ASSUMPTIONS FOR 1975 AND 2000

Year	*World*	*Africa*	*Northern America* [a]	*Latin America* [b]	*Asia* [c]	*Europe, incl. USSR*	*Oceania*
1900	100.0	7.7	5.2	4.1	55.3	27.3	0.4
1925	100.0	7.7	6.6	5.2	53.5	26.5	0.5
1950	100.0	8.0	6.7	6.5	55.2	23.0	0.5
1975	100.0	7.9	6.3	7.9	57.7	19.6	0.5
2000	100.0	8.2	5.0	9.4	61.8	15.1	0.5

[a] America north of Mexico.
[b] America south of the United States.
[c] Excluding the Asiatic part of the USSR.

As table 5 shows, the population of most continents and of the world as a whole is likely to be quadrupled in the course of our century; the exceptions are Europe (including the Soviet Union) whose population nevertheless more than doubles, and Latin America, whose population is likely to increase ten-fold. These increases, however, are differently distributed among the several quarter-centuries.

As can be inferred from table 6, the rate of world population growth will probably continue to rise until the end of the century, despite past fertility declines in western countries and Japan, and despite fertility declines beginning in 1975 projected for other areas on the medium assumptions. High rates of growth in the Americas and Oceania during the 1900-1925 period are associated with relatively large-scale immigration; it is unlikely that immigation will be of similar impact in the future as the indigenous populations themselves have become large. Because of fertility decline, rates of increase in Northern America, Europe and Oceania, diminish considerably in the 1925–1950 period. In both of these quarter-centuries, moreover, population growth in Europe, including the Soviet Union, is also affected by the heavy losses incurred in two world wars.

Because of declining mortality, population increase will probably be accelerated throughout the century in Africa, Latin America and Asia, even if it is admitted that, after 1975, fertility may decline. Low mortality and moderate or low fertility determine the rates of increase estimated for Europe, North America and Oceania; the two latter continents will be further affected by the recent resumption of immigration.

Resulting changes in the distribution of world population among continents appear in table 7. Africa's share in the world total may change, but only slightly. The proportions for Northern America and Oceania have been rising until the middle of the century, but are likely to fall off again. Latin America's share in the world population will increase throughout the century, outstripping the populations of both Nothern America and Africa within the 1950–1975 period. More then half of the world's people live in Asia, and the proportion is likely to surpass three-fifths before the century is ended. There will be a continuous decline in the relative importance of Europe, including the Soviet Union. Early in the century, there was one European for every two Asians; by the end of the century, this ratio may have become one to four.

The relative changes in continental and regional population will have major repercussions on the terms of trade for raw materials and finished products. Because of a rapid increase in the number of local consumers, raw materials exported from certain countries will become scarce. Markets for finished goods produced elsewhere may widen, but a scarcity of materials may render their production costly. Changes in technology, economic organization and structure may or may not offset some of these effects of differing rates of population growth.

E. POPULATION DENSITY AND RATES OF POPULATION GROWTH, BY REGIONS

The rough projections of regional population are not adequate for any detailed study of the problems affecting each area. The figures, nevertheless, provide illustrative material to highlight some of the major long-range problems, in the context of a world-wide comparison. Two aspects must now be considered: the density of population per unit of land, and the rate of population growth. Reference is made to the nineteen regions, already defined.

Vast differences in climate, terrain, and accessibility to transport among the regions of the world deprives a comparison of regional population densities of any exact meaning. Parts of some of the regions consist of Arctic wastes, deserts, or high mountains where little human settlement, so far, has been possible. Among lands equally endowed by nature, differences in social organization, productive techniques, and accepted living standards introduce further variations into the meaning of population density. However, no other measure has so far been devised which permits making a more significant comparison of the relation of population to available resources in each given area, on a world-wide basis. The ratio between population and surface area remains the index which appeals most readily to the imagination and therefore it is useful, provided its severe limitations as a measure of population pressures are fully kept in view.

Table 8 shows the number of inhabitants per square kilometre of land area in each of the nineteen regions,

TABLE 8. NUMBER OF INHABITANTS PER SQUARE KILOMETRE OF LAND AREA IN 19 REGIONS OF THE WORLD, IN 1950 AND, ACCORDING TO HIGH AND LOW ASSUMPTIONS, IN 1975 AND 2000

Region	Area (thousand km²)	Density (persons per km²)		
		1950	1975	2000
Australia and New Zealand	7 970	1.3	2	2–3
Southern Africa	2 840	4.9	8–9	12–18
Pacific Islands	585	5.0	9	15
Tropical South America	13 700	6.2	11–12	18–27
Temperate South America	4 160	6.5	10	12–14
Middle Africa	21 600	6.6	9–11	13–21
Northern Africa	5 820	7.3	12–13	19–28
Northern America	21 500	7.8	11	13–15
USSR	22 300	8.1	12	15–18
South-West Asia	5 550	11	19–21	28–41
Central America	2 510	14	27–29	44–66
South-East Asia	4 490	38	58–62	83–122
East Asia (without Japan)	11 500	52	77–83	110–163
Northern and Western Europe	2 250	59	66–68	70–83
Caribbean	236	69	106–115	153–223
Southern Europe	1 660	79	95–100	105–129
Central South Asia	5 140	91	132–143	190–280
Central Europe	1 010	130	149–154	158–188
Japan and Ryukyu Isl.	372	225	296–315	336–427

as estimated for 1950 and projected for 1975 and 2000. For the projected figures, the range between the results of the high and low assumptions is presented.

In 1950, through historical and geographical causes, ten regions were inhabited with average densities lower than 10 per square kilometre; only three or four of these will retain densities of less than 10 until 1975, and only one (Australia and New Zealand) until 2000. At the other extreme, only in two regions (Central Europe, and Japan) did average densities exceed 100 to the square kilometre in 1950; regions inhabited at densities greater than 100 will probably number four in 1975, through the addition of the Caribbean and Central South Asia; by the year 2000, their number will probably be six or seven. The densities of some regions, because of more rapid growth, will eventually outstrip those of other regions. Densities in some Asian regions will surpass those of European regions. Densities in Africa and South America will exceed those in Northern America and the Soviet Union.

The exact meaning of these densities will depend in part on the endowment of the land with physical resources but to an increasing extent on the methods and techniques used in the rational exploitation, transformation and distribution of the materials available to meet human needs. The use of nuclear energy or plant mutations, or success in attempts to influence the weather may render more hospitable some of the areas where drought, cold, or high altitude have hitherto prevented human settlement. Sanitation programmes have already made habitable many of the low-lying areas where previously malaria and other diseases constituted a permanent threat. In view of these and similar technical developments, it is probable that regional man-land ratios in the future will furnish a better gauge of relative population pressures than they do now.

If population growth continues unabated, all world regions will eventually be inhabited to the full extent which their resources, skill in their use, social organization, and human endurance permit. Dangerous degrees of population pressure, meanwhile, will be reached in different parts of the world at different times. Since time is always needed in making adjustments to new circumstances, the speed with which such pressures are being built up is an important factor. High densities, if attained gradually, may pose less serious problems than more moderate densities which arise from rapid growth. In addition to this question of time, the rate of population growth has also direct effects on the dynamics of economic development and social change.

Table 9 shows the estimates of regional populations for 1925, 1950 and for 1975, resulting from high and low assumptions in the projections;[3] the corresponding percentage increases per 25-year period are also indicated, and so is the increase according to the medium assumption expected from 1950 to 2000.[4]

The regions have been ranked in the order of expected population increases in the remainder of this century, according to the medium assumption. It will be observed that the order of the regions according to expectations for 1950–1975, is roughly the same as that according to observations for 1925–1950.

[3] It must be remembered that the high assumption is regarded as the more probable one up to 1975, except for Middle Africa.

[4] The medium assumption for 1975–2000, continues the trend of the high assumption up to 1975 for all regions except Middle Africa, where it continues the trend of the low assumption.

TABLE 9. ESTIMATED POPULATION OF 19 REGIONS OF THE WORLD IN 1925, 1950, AND 1975 ON HIGH AND LOW ASSUMPTIONS, PERCENTAGE INCREASES IN 1925–1950 AND 1950–1975, AND INCREASE FROM 1950 TO 2000 (MEDIUM ASSUMPTION)

Region	Population (millions)			Increase (per cent)		Population in 2000 per 100 population in 1950
	1925	1950	1975	1925-50	1950-75	
Central America	21.0	34.7	66.6–72.3	65	92–108	432
Tropical South America	50.6	84.4	150–163	67	78–93	402
Northern Africa	29.0	42.7	70.4–76.4	47	65–79	344
Southern Africa	8.7	13.9	22.5–24.4	60	62–76	339
South-West Asia	45.9	63.3	107–116	38	69–83	325
Pacific Islands [a]	2.2	2.9	5.0	32	71	297
Caribbean	10.5	16.3	25.1–27.1	55	54–66	294
South-East Asia	118	171	259–280	45	51–64	291
East Asia (without Japan)	453	595	884–958	31	49–61	286
Central South Asia	343	466	680–737	36	46–58	281
Middle Africa	109	142	202–230	30	42–62	227
USSR	163	181	266–275	11	47–52	209
Temperate South America	17.2	27.2	40.4–41.7	58	49–53	205
Australia and New Zealand	7.4	10.2	15.5–16.0	38	52–57	204
Northern America	126	168	232–240	33	38–43	186
Japan and Ryukyu Islands	59.7	83.6	110–117	40	32–40	183
Southern Europe	105	132	158–166	25	20–26	156
Central Europe	117	128	151–156	9	18–22	143
Northern and Western Europe	120	133	149–154	11	12–16	135

[a] For this region, no alternative assumptions were made.

More particularly, greater relative increases are to be expected for all regions except two in 1950–1975,[5] than occured in 1925–1950. Not all statistical observations for the latter period, are reliable, and relatively heavy losses in population were incurred during the Second World War in the Soviet Union and in Central Europe. The recurrence of such a disaster in the future is not here predicted for any one region, but the possibility subsists.

High rates of population growth, in all probability, will be more prevalent in 1950-1975 than they were in 1925–1950. This becomes apparent if we count the numbers of world regions for which average annual rates of growth greater than 2 per cent, or conversely smaller than 1 1/2 per cent, have been estimated: in a 25-year period, a population growing constantly at 2 per cent gains 64 per cent of its initial number; one growing at 1 1/2 per cent gains slightly more than 45 per cent.

During 1925–1950, average annual rates of 2 per cent were exceeded in Central America and Tropical South America, and average rates of 1 1/2 per cent in Northern Africa, Southern Africa, the Caribbean region, and Temperate South America. In the remaining thirteen regions, average rates of growth in 1925–1950 were less than 1 1/2 per cent. By contrast, in 1950–1975, an average annual growth by more than 2 per cent is to be expected in at least five, and possibly seven regions, while an average annual growth of less than 1 1/2 per cent may occur in five or six regions only. Slower growth may occur in some regions, according to medium or low assumptions, in the 1975–2000 period.

F. REGIONS OF HIGH OR LOW DENSITY, RAPID OR MODERATE GROWTH

By combining the information presented in tables 8 and 9, four categories of regions can be distinguished, having reference to the population densities already attained in 1950 and to expected rates of population growth. The dividing lines to be drawn are at best speculative, since future estimates depend on assumptions which, though plausible, still remain to be borne out by fact. Furthermore, diverse conditions are found among areas within each region, especially the Pacific Islands and the Caribbean. However this may be, sharp contrasts will be noted when regions are grouped as follows: [6]

[5] Temperate South America and Japan. To these one may add Southern Europe, where the increase estimated for 1950–1975 is not sensibly greater than that in 1925–1950. These three regions, and the Soviet Union, are the ones in which fertility has declined rather recently, resulting in a slower population growth despite a lower mortality. The Soviet Union, however, incurred severe human losses during the Second World War and some doubt remains whether recent estimates of its population are really comparable with those for an earlier period, bearing in mind its present boundaries.

[6] The criteria for grouping, admittedly arbitrary, were the following: (*a*) population densities above or below the dividing line of 30 persons per km² in 1950; and (*b*) an average annual rate of growth of 1 1/2 per cent according to medium assumptions, for 1950–2000, resulting in a medium estimate, for the year 2000, above or below the dividing line of 210 per 100 persons estimated for 1950.

1. *Low density, moderate growth :* Northern America, Temperate South America, Australia and New Zealand, and the Soviet Union;

2. *Low density, rapid growth :* The three regions of Africa, Central America, Tropical South America, South-West Asia and the Pacific Islands;

3. *High density, moderate growth :* The three European regions and Japan; and

4. *High density, rapid growth :* The Caribbean, Central South Asia, South-East Asia and East Asia (excluding Japan).

Some of the combined characteristics of these four groups of world regions are shown in table 10 below.

Areas of low density (Groups 1 and 2) occupy about 80 per cent of the world's land surface (excluding the Antarctic continent). In 1950, they contained 30.9 per cent of the world's population; this percentage is likely to attain only 31.8 in 2000, according to the medium assumption. For the remaining 20 per cent of the land area, in which almost 70 per cent of the world population is concentrated, the density figures shown in table 10 are far from adequate. Group 3 contains the sub-arctic and mountainous portions of Europe in which population density is, and will probably remain low. Group 4 consists mainly of southern and eastern Asia, which include vast interior tracts of the high mountain massifs, deserts and semi-deserts of inner Asia; certainly 99 per cent of the population of monsoon Asia are found within an area smaller than one-half of that of the regions as defined here. No clear delimitation can be made between areas suitable for human habitation and those unsuitable, except in the rather obvious case of the Antarctic continent. But, considering the expanse of waste land present in regions of each type, one may regard average current densities of about 10 persons to the square kilometre as typical for regions of groups 1 and 2, while average densities in the more hospitable portions of regions in groups 3 and 4 are already clearly in excess of 100. In accordance with this rather vague criterion, typical average densities to the square kilometre expected by the end of the century would be about 20 in regions of group 1, about 30 in group 2, about 150 to 200 in group 3, and over 300 in group 4.

The detailed population problems differ in each area and locality, and change from time to time. Action programmes designed to meet these problems are concerned with each detailed situation, and with changes to be expected within the relatively short periods for which practical planning is possible. For such purposes, the study undertaken here is far from adequate. It can only highlight some of the contrasting conditions found in the world today, or expected changes which may occur in the long run. Viewed in this very broad perspective, the prevalent types of problems differ between the areas of the world somewhat as follows :

In regions of low density and moderate growth, notably Northern America, the Soviet Union, and areas of European settlement in the Southern hemisphere, the problem is not over-all population pressure. Subtle and yet important problems nevertheless subsist, which the figures presented here cannot illustrate. Economic growth involves transfers of the active population from one sector of activities to another, as well as a substantial geographic re-grouping of these activities. Relative dispersion or heavy concentration of the population in certain areas has important advantages but also serious drawbacks in terms of transportation costs and the integration of activities; either requires detailed study of the composition, geographic distribution, and migratory mobility of the populations concerned.

To these problems, others are added in regions of low density and rapid growth. In varying degrees, depending on the stage and tempo of economic development, on the rigidity of social structures, and on the extent

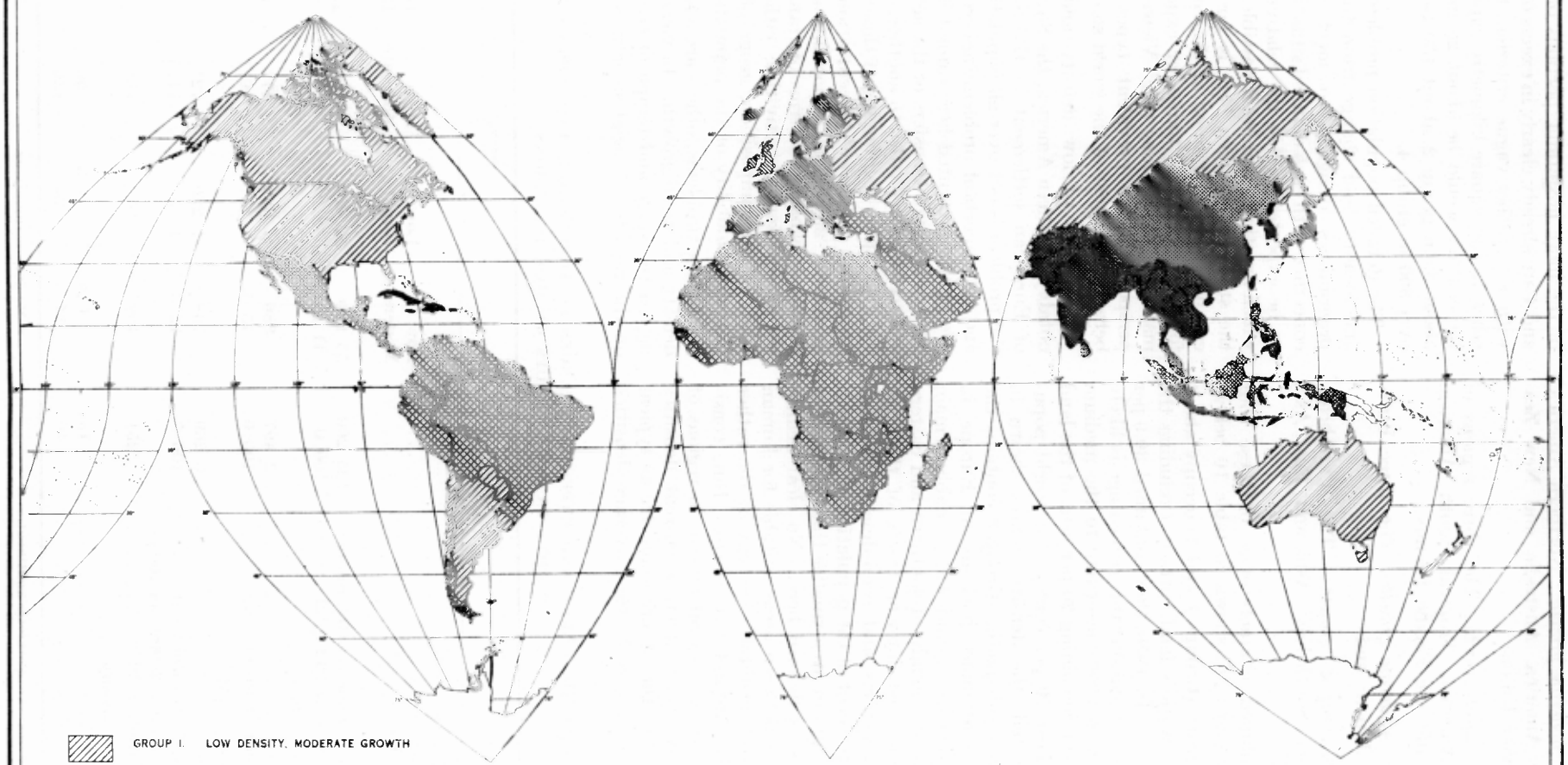
TABLE 10. AREA AND EXPECTED CHANGES IN POPULATION, AND POPULATION DENSITY IN FOUR GROUPS OF WORLD REGIONS

		Group			
	World [a]	*1*	*2*	*3*	*4*
Characteristics					
Density	...	Low	Low	High	High
Expected growth	...	Moderate	Rapid	Moderate	Rapid
Area					
Square kilometres (thousands)	135 200	55 900	52 600	5 300	21 400
Per cent of world total	100.0	41.3	38.9	3.9	15.8
Population, 1950					
Millions	2 497	386	384	477	1 250
Per cent of world total	100.0	15.5	15.4	19.1	50.1
Population, 2000 [b]					
Millions	6 269	768	1 220	721	3 560
Per cent of world total	100.0	12.3	19.5	11.5	56.8
Population in 2000 [b] per 100 population in 1950	251	199	318	151	285
Population density					
1950	18	6.9	7.3	90	58
2000 [b]	46	14	23	136	166

[a] Excluding the Antarctic continent.

[b] Medium assumptions.

WORLD REGIONS
BY POPULATION DENSITY AND RATE OF GROWTH



GROUP I. LOW DENSITY, MODERATE GROWTH

GROUP II. LOW DENSITY, RAPID GROWTH

GROUP III. HIGH DENSITY, MODERATE GROWTH

GROUP IV. HIGH DENSITY, RAPID GROWTH

SINUSOIDAL EQUAL-AREA PROJECTION

0 1000 2000 3000
MILES

0 1000 2000 3000
KILOMETRES

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

MAP NO. 1004
JANUARY 1958

UNITED NATIONS

of cultural resistance to disrupting influences, these problems concern large parts of Latin America, Africa, and the Near East. Some segments of the social and economic structure are more rigid than others and therefore relatively unable to absorb rapid increases in population. The result is an increasing relative surplus of the population which becomes dissociated from existing ties in the villages or tribes and seeks integration in new environments and activities, for which an economic basis has yet to be created. The problems connected with urbanization in such areas are notoriously acute. Because of their comparatively low population densities, the technological problem of an efficient use of resources should not be insuperable, but it is severely aggravated by rigidities of their social structure which are ill-suited to a rapid absorption of added numbers in the population.

The problems in areas of high density and moderate growth, notably Europe and Japan, are quite different. With the existing demographic structures, these areas will eventually cease to be threatened by a severe imbalance arising from demographic trends. Because of past trends, growth is still inherent in the populations of Japan and Southern Europe, but this factor will be of rapidly diminishing importance. It is to be noted that in areas of this group, the current birth rates are now generally the lowest in the world. The maintenance of an adequate level of living in areas of high density depends on a highly efficient use of resources available both within and without these areas themselves. Technology, effective economic organization, and the preservation of satisfactory terms of trade are among the prerequisites for the well-being of people living in such areas. Because of their declining share in world population, they may find the solution of such problems relatively easier in the more distant future, provided that adequate terms of trade with other parts of the world can be secured on a continuing basis.

Fully one-half of the world's people live in monsoon Asia. Within this general region the concentration in particular areas is already outstandingly great. Current economic and social conditions even now present the greatest challenge to human ingenuity in seeking effective remedies to existing poverty. The problem is all the more baffling because of the large increases in population which must be expected. A continued decline in mortality is rendered feasible by modern devices which, because of their inexpensiveness, can be effectively applied in poverty-stricken areas; man's innate insistence to prevent avoidable deaths and disease makes their further application practically inevitable. But a commensurate decline in fertility does not follow directly from mortality decline, and no evidence can, as yet, give any support to an expectation that fertility levels will decrease appreciably within the near future. Even if they do, the existing age structure of the population will continue to favour rapid growth for some time to come.

The high density and rapid growth of fully one-half of the world's population constitutes a world problem of the first order. In this context, the advocacy of policies designed to slow down the increase of populations by the Government of India and, quite recently, also by the Government of the People's Republic of China deserves the closest attention of the rest of the world.

Chapter III

BIRTH RATES, DEATH RATES, AND POPULATION STRUCTURE

In addition to projecting total numbers of the population, the models presented in Chapter I can also serve in a study of the inherent dynamics of population change and of the numbers of births, deaths, and individuals in each group which can consequently be expected. Some of these aspects will be presented here.

The figures on total population discussed in chapter II, were obtained from models after adjustment of their theoretical rates of growth to coincide with statistical observations of a base period (1950–1955). Similar adjustments to theoretically estimated birth rates, death rates and age structures cannot be made without laborious calculations, for which neither enough time nor sufficient knowledge of certain detailed facts is available. The unadjusted estimates presented in this chapter, though only rough approximations to the facts, nevertheless furnish a useful illustration of a dynamic process. Since some of the errors in the estimates are likely to compensate each other, the theoretical estimates for continents and the world are probably more realistic than those for individual regions.[1]

A. Birth rates, death rates, and rates of natural increase

Current vital rates of the populations of continents and the world can be estimated by two different methods, the " statistical " and the " demographic ".

The first method consists in the marshalling of the available direct evidence of vital statistics. Data on births and deaths are quite accurate in some regions, and in a few—not always the most representative—countries of other regions. For many countries, the statistics are of an undetermined degree of accuracy, but their defects are not readily apparent. For others, they are either patently inadequate or are not reported at all. The statistical method consists, then, in the utilization of all evidence there is no very obvious reason to reject and an assumption that some areas with apparently adequate statistics are representative of others without such statistics and where conditions had not to be regarded as necessarily different.

The great advantage of this method is that the estimates so obtained stay clearly within the limits of available direct evidence: though this evidence be of varying quality, each figure is directly related to facts as they have been observed. The method is unimpeachable for areas with statistics of demonstrated accuracy. For other areas, additional evidence is required for the support of alternative estimates which, of course, is far less direct than the more immediately available records of vital statistics.

The demographic method, on the other hand, facilitates the calculation of those birth rates and death rates which correspond to the general structure and dynamics of a population. The construction of models ensures that vital rates are fully consistent with age composition, at least in a theoretical sense. Refined computations are necessary, if the calculated structure and dynamics of a model are to coincide very closely with those of an actual population. Limitations of time and accurate knowledge have made it necessary to keep the models presented here as simple as possible. While thoroughly coherent, these models approximate reality only so far as their simplicity permits. The theoretical estimates so obtained are poor substitutes for those derived directly from statistical compilations for areas where the statistics are of high quality. For areas with incomplete or fragmentary statistics, it is doubtful which of the two methods merits the greater confidence. The chief advantage of the demographic method is that it provides a coherent picture of dynamic change, the necessary relations of which are not brought to light directly in a compilation of observed vital rates. Another possible advantage is that, since models have been constructed upon preliminary considerations about the most probable variations in fertility and mortality, the errors they contain are not necessarily biased in one direction; estimates based on available statistics, on the other hand, tend to fall below the actual figures where some of the statistical recordings are incomplete to an undetermined degree.

Statistical estimates of birth rates and death rates in various parts of the world have recently been published in the United Nations Demographic Yearbook.[2] These, together with the birth rates and death rates resulting in the population models used here, without

[1] A comparison of theoretically calculated birth rates, death rates and age structure with statistical observations for each region is made in the " Note on the adequacy of the models as applied to particular regions ". From this analysis, some conclusions are drawn as to the probable errors involved in applying directly the unadjusted models to the regional populations. With regard to age structure the errors are comparatively small (see also part C of this chapter).

[2] *Demographic Yearbook 1956* (United Nations publication, Sales No. : 1956.XIII.5), table A, page 2 of chapter I. The explanatory text states that " The birth and death rates were chosen by studying the range of these statistics in the countries of each region in which statistics are believed to be complete or for which there are objective estimates of birth and death rates ", account also being taken of rates of population growth observed from censuses and official estimates of total population.

TABLE 11. BIRTH RATES, DEATH RATES, AND RATES OF NATURAL INCREASE OF CONTINENTS AND THE WORLD: ESTIMATES DERIVED FROM AVAILABLE STATISTICS, 1951–55, AND THEORETICAL ESTIMATES DERIVED FROM SIMPLIFIED POPULATION MODELS, 1950

Continent	Estimates derived from statistics, 1951-55[a]			Estimates derived from population models, 1950[b]		
	Birth rate	Death rate	Natural increase	Birth rate	Death rate	Natural increase
World	34	18	16	39	25	14
Africa	45	25	20	47	33	14
Northern America	25	9	16	22	9	13
Latin America	42	18	24	40	19	21
Asia	39	22	17	46	33	13
Europe	20	11	9	20	9	11
Oceania	25	8	17	26	12	14
USSR	26	9	17	25	7	18

[a] Demographic Yearbook, 1956, table A, page 2. Weighted averages for continents.
[b] Corresponding to population models used in this study, not adjusted to accord with specific statistical observations.

adjustment to specific observations in a base period, are presented in table 11. Figures relating to regions have been combined in continental and world totals.[3]

In the case of Northern America and Europe, the statistically derived estimates are undoubtedly more accurate than the approximations obtained from the models. This is also probably true of Latin America and the USSR, though more evidence would be needed to demonstrate the accuracy of available statistics. For Africa, Asia, and parts of Oceania, statistics are fragmentary or incomplete, with the probable result that the statistically compiled figures are underestimates; though the estimates deduced from models may also be affected by considerable error, their order of magnitude, as emerges from the analysis presented in the appendix "Note", is likely to come closer to the actual facts.

[3] For two regions, as explained in chapter I, no precise models could be used. Substitute estimates have been made here by assuming that birth rates, death rates and population structure in the Caribbean and Pacific Islands regions are the same as they are in the combined regions of Latin America (i.e., Central America, Tropical South America, and Temperate South America, without inclusion of the Caribbean).

The models, moreover, place the birth and death rates at average trend values which might have resulted in 1950, in the absence of migration. While the average birth rate observed in Northern America during 1951–55 was 25 per 1,000, it is still possible that a lower figure more nearly coincides with the trend value. The theoretically estimated death rates for Europe and the Soviet Union of 9, and 7 per 1,000 respectively would result from the probable age structures of these populations if the average expectation of life at birth in 1950 had been 68.2 years, a figure not yet attained at that time; further progress in the prevention of deaths, nevertheless, may align the crude death rates of these regional populations with those of the models within the very near future.

Of greater interest than the absolute values of the vital rates implied in the population models are the changes which can be expected in the future. The theoretical rates estimated for 1950, 1960 and 1975 are assembled in table 12, corresponding to medium assumptions of future change, i.e., constant fertility and declining mortality except in the case of Middle Africa, where the assumption is one of constant fertility and constant mortality.

TABLE 12. ANTICIPATED CHANGES IN THEORETICAL BIRTH RATES, DEATH RATES, AND RATES OF NATURAL INCREASE OF CONTINENTS AND THE WORLD, 1950–1975, ACCORDING TO MEDIUM ASSUMPTIONS[a]

Continent	1950			1960			1975		
	Birth rate	Death rate	Natural increase	Birth rate	Death rate	Natural increase	Birth rate	Death rate	Natural increase
World	39	25	14	37	21	16	37	17	20
Africa	47	33	14	47	31	16	46	29	17
Northern America	22	9	13	20	9	11	21	9	12
Latin America	40	19	21	40	16	24	40	12	28
Asia	46	33	13	44	27	17	43	20	23
Europe	20	9	11	18	9	9	18	10	8
Oceania	26	12	14	24	10	14	26	10	16
USSR	25	7	18	24	6	18	22	7	15

[a] The assumption is one of constant fertility and declining mortality, except in Middle Africa, where mortality is also assumed to remain constant. Vital rates in the Caribbean and the Pacific are assumed to be the same as for the average of the Latin American regions other than the Caribbean.

With constant fertility, minor changes in crude birth rates can result from the expected changes in age structure. In most instances, the effect is a slight decrease in the crude birth rate, though births to women of child-bearing age remain as frequent as before.

For death rates, the normal expectation is one of considerable decline, except for large parts of Africa, where this tendency so far has not been definitely established. The progressive aging of the population of Northern America, Europe and the Soviet Union will result in approximately constant crude death rates, although, in each age group separately, risks of death will decline further. The assumption of a normal mortality decline entails a considerable decrease in the death rates of Latin America, and a spectacular drop in those of Asia where, in view of current mortality levels, progress can be particularly rapid.

Large decreases in death rates, coupled with almost negligible decreases in birth rates, result in a considerable acceleration of the rates of natural increase in Africa, Latin America and Asia. Because of changes in age structure, the assumed fertility and mortality trends in Northern America, Europe and the Soviet Union entail a gradual slowing-down of population growth. For the world as a whole, natural increase will be greatly augmented.

The low assumptions, for regions other than Middle Africa, imply declines in fertility. These may occur in some areas, but it is unlikely that they will occur simultaneously in all regions composing each continent, or in all continents of the world. If the low assumptions were to prove correct in all regions of the world, the resulting changes in vital rates would be those shown in table 13. In Africa, Latin America and Oceania, the decrease in crude birth rates would be about equal to that in crude death rates, resulting in little change of the natural increase. In Northern America, Europe, and the Soviet Union, birth rates would decline while crude death rates would remain nearly constant, and the natural increase would diminish accordingly. In Asia, the assumed rate of fertility decline would be insufficient to offset the rapidly decreasing death rates and the natural increase would still be augmented, though not as much as on the medium assumptions.

TABLE 13. CHANGES IN THEORETICAL BIRTH RATES, DEATH RATES, AND RATES OF NATURAL INCREASE OF CONTINENTS AND THE WORLD, 1950–1975, ACCORDING TO LOW ASSUMPTIONS [a]

Continent	1950			1975		
	Birth rate	*Death rate*	*Natural increase*	*Birth rate*	*Death rate*	*Natural increase*
World	39	25	14	30	17	13
Africa	47	33	14	44	29	15
Northern America	22	9	13	18	9	9
Latin America	40	19	21	32	12	20
Asia	46	33	13	35	19	16
Europe	20	9	11	15	10	5
Oceania	26	12	14	24	10	14
USSR	25	7	18	19	7	12

[a] The assumption is one of declining mortality and declining fertility, except in Middle Africa, where both mortality and fertility are assumed to remain constant.

B. NUMBERS OF BIRTHS AND DEATHS

At the present time, about three births and two deaths occur in the world every second. In 20 years, one may expect about four births and two deaths per second. There are, of course, more than 30 million seconds in a year. Two out every three births and almost three out of every four deaths occur at present in Asia. These and some other facts can be noted from table 14, in which are brought together the absolute numbers of births and deaths, according to unadjusted models, on medium assumptions. Because no claim can be made for accuracy, all figures are shown to two significant digits only.

In the 25-year period, the annual number of births probably will almost double in Latin America, will increase by one-half in Africa and Asia, and will change but little in Europe. By contrast, the annual number of deaths may remain almost unchanged in Asia, but will rise by one-quarter to one-half in other continents.

In 1950, population growth in Asia amounted to little more than one-half of world population growth but by 1975 it is likely to have become two-thirds. In Europe, population growth will tend to slow slightly, and will be outstripped by the annual growth in Latin America, Africa, and eventually the Soviet Union.

The figures bring to light the tremendous turnover in human lives on which population growth in Africa and Asia depends. Though twice a large as that of Africa, the population of Europe subsists on fewer births and fewer deaths than the population of Africa, while the number of births and deaths in Europe is of the order of one-tenth of those in Asia. Because of age structure, population growth is particularly favoured in the Soviet Union. Thus, under the conditions estimated for the year 1960, the Soviet population increases by one unit for every 1.4 births; while for every unit increase of the population in Northern America, Latin America and Oceania there

TABLE 14. ANNUAL NUMBERS OF BIRTHS AND DEATHS, AND ANNUAL POPULATION INCREASE, BY CONTINENT, INFERRED FROM UNADJUSTED DEMOGRAPHIC MODELS, IN 1950, 1960, and 1975 (MEDIUM ASSUMPTIONS)

Continent	Births (thousands)			Deaths (thousands)			Increase (thousands)		
	1950	1960	1975	1950	1960	1975	1950	1960	1975
World	96 000	110 000	140 000	62 000	61 000	66 000	34 000	47 000	75 000
Africa	9 400	11 000	14 000	6 500	7 300	8 800	2 900	3 700	5 300
Northern America	3 700	3 900	5 100	1 600	1 800	2 200	2 100	2 200	2 900
Latin America	6 600	8 200	12 000	3 000	3 200	3 700	3 500	5 000	8 400
Asia	64 000	72 000	95 000	46 000	43 000	45 000	18 000	29 000	50 000
Europe	7 800	7 500	8 400	3 600	3 800	4 600	4 200	3 700	3 800
Oceania	340	400	540	150	170	210	190	230	330
USSR	4 500	5 100	6 100	1 200	1 300	1 800	3 200	3 800	4 300

are 1.7 to 1.8 births, and in Europe, one unit is added to the population for every 2.0 births, in Asia for every 2.5 births, and in Africa for every 3.0 births.

These ratios will change in the course of time, partly because of declining mortality and partly because of changes in age structure. As estimated here, world population increases by one unit for every 2.8 births occuring in 1950, for every 2.3 births in 1960, and for every 1.9 births in 1975 (for every 2.2 births in 1975 on the low assumption).

C. CHANGES IN AGE STRUCTURE

A discrepancy was noted between estimates of birth rates and death rates obtained by two different methods. But, as regards age composition, the demographic method agrees very well with the results of statistical compilations for continental and world populations. This fact, as will be argued further on, can be taken as evidence that the demographic models used here are quite appropriate to their purpose.

Available statistics on population age structure come from countries where censuses have been taken and the results could be satisfactorily tabulated by age groups. These countries are not fully representative of all regions, nor of the world as a whole; and the statistics are inaccurate owing to the frequent omission of small children from the census count and owing to the tendency of elderly persons to exaggerate their age. Defects in the demographic models must also be taken into account. Nevertheless, the results of both methods coincide so closely as to give much justification for the use of models in calculating estimates.

In table 15, a comparison is made between estimates of population structure recently assembled from census data in the Demographic Yearbook [4], and the estimates which derive from our models, without adjustment to more specific statistics. The probable defects of available statistics suffice to account for most of the discrepancies between the two sets of estimates. Exaggeration of old age or the unrepresentativeness of enumerated populations may have resulted in the somewhat higher percentages of persons aged 60 years and over according to censuses in Africa, Asia, Europe, and Oceania (or the lower percentage in Latin America).

[4] *Demographic Yearbook 1956*, op cit., table B, page 8.

TABLE 15. COMPARISON OF ESTIMATES OF AGE COMPOSITION OF THE POPULATION OF THE WORLD AND CONTINENTS, ACCORDING TO CENSUSES TAKEN AROUND 1950, AND ACCORDING TO DEMOGRAPHIC MODELS FOR 1950

Continent	Percentage distribution of enumerated population by age [a]			Percentage distribution of estimated population by age		
	Under 15	15-59	60 and over	Under 15	15-59	60 and over
World	34 [b]	58	8	37	56	7
Africa	42	52	6	42	54	4
Northern America	27	61	12	27	61	12
Latin America	40	55	5	40	54	6
Asia	38	56	6	40	55	5
Europe	25	62	13	26	62	12
Oceania [c]	30	61	12	30	59	11
USSR [d]	—	—	—	33	59	8

[a] Population of 142 countries, according to censuses taken during 1945–1954. Source: *Demographic Yearbook* 1956, op. cit., page 8, table B. Weighted average of enumerated populations.

[b] Weighted average of populations enumerated in the world. If it is assumed that 40 per cent of the population in China Mainland and 32 per cent of the population in the USSR are under 15 years of age, this percentage would be 36 *(Demographic Yearbook 1956)*.

[c] Figures on enumerated population in source probably in error, since their sum exceeds 100 per cent.

[d] No census age distribution was obtained within the 1945–1954 period.

An under-enumeration of infants may be the reason why the statistics show a lower percentage at ages under 15 in Asia than do the models. As regards the Soviet Union, there are no recent statistics on age structure, and it is questionable whether the demographic estimates approximate the facts, the model being, undoubtedly, a gross over-simplification of actual trends in that country.

According to estimated figures, two types of populations can readily be distinguished: in Africa, Latin America and Asia, the percentage of persons aged under 15 is 40 or more, and the percentage of persons aged 60 and over is 6 or less; in Northern America, Europe and Oceania, the percentage of persons aged under 15 is 30 or less, and the percentage of persons aged 60 or over is 11 or more. In the Soviet Union, the population structure, apparently, is of an intermediate category, but the precise conditions are not really known.

The populations of Northern America, Europe, Oceania and the USSR are in the process of aging: the percentage of children has been reduced, and that of older persons is rising. Up to 1950, the increase in the proportion over 60 had not so far equalled the decrease in the proportion under 15, with the result that larger segments remain within the age groups generally associated with productive work and self-support. The proportions at ages 15-59, accordingly, are 59 per cent or more in these continents, as contrasted with 55 per cent or less in Africa, Latin America and Asia.

The changes in age structure which should be anticipated on the medium assumptions are those indicated in table 16.

TABLE 16. EXPECTED CHANGES IN AGE COMPOSITION OF THE POPULATION OF THE WORLD AND CONTINENTS, 1950–1975

	Estimated percentage distribution of population at various ages								
	1950			*1960*			*1975*		
Continent	*Under 15*	*15-59*	*60 and over*	*Under 15*	*15-59*	*60 and over*	*Under 15*	*15-59*	*60 and over*
World	37	56	7	37	56	7	38	54	8
Africa	42	54	4	41	55	4	41	54	5
Northern America	27	61	12	28	58	14	28	56	16
Latin America	40	54	6	40	54	6	42	52	6
Asia	40	55	5	40	55	5	41	54	5
Europe	26	62	12	26	60	14	24	59	17
Oceania	30	59	11	31	57	12	31	55	14
USSR	33	59	8	31	60	9	30	59	11

Since constant fertility is assumed, changes in the percentage of individuals aged less than 15 will in most cases be slight, except in the Soviet Union, where fertility seems to have declined somewhat recently, though in this case the estimates may be misleading. In Africa, Latin America and Asia, despite anticipated declines in mortality, there will be little change in the small proportion of persons aged 60 years and over. Continued and considerable aging, on the other hand, will occur in Northern America, Europe, Oceania and the Soviet Union. As a result, much of the advantage of the relatively large segment at ages 15-59 will eventually be lost. The relative contraction of this group will be especially marked in Northern America, where the recent rise in fertility has increased the segment of children while the process of aging continues unabated.

D. NUMBERS OF POPULATION BY AGE GROUPS

It is worth while to translate the percentages of table 16 into absolute numbers of persons aged under 15, 15-59, and 60 and over, respectively. This is done in table 17, below. Figures, to two significant digits, are shown for each continent and the world, as they result from unadjusted models, according to the medium assumptions, in 1950 and 1975.

In 1950, Northern America, Europe, Oceania and the USSR had a combined child population (aged less than 15) of 210 million, compared with the 700 million children of Africa, Latin America and Asia; the number of aged people, on the other hand, was more than 80 million (half of the total) in the first-mentioned four regions, but less than 80 million in the latter three.

By 1975, the contrast is likely to have sharpened further. Northern America, Europe, Oceania and the USSR can be expected to have about 275 million children and more than 150 million aged persons; in Africa, Latin America and Asia, the number of children will probably exceed 1,100 million, while aged persons will number less than 150 million.

The age distributions of the models are in groups of five years, making it possible to present continental and world totals in much greater detail. Estimates

TABLE 17. ESTIMATED NUMBERS OF PERSONS AGED UNDER 15, 15-59, AND 60 AND OVER, IN 1950 AND 1975, BY CONTINENT, ACCORDING TO " MEDIUM " ASSUMPTIONS (IN MILLIONS)

Continent	Population (millions) at various ages					
	1950			1957		
	Under 15	15-59	60 and over	Under 15	15-59	60 and over
World	910	1 400	160	1 400	2 100	300
Africa	81	110	8.7	130	160	14
Northern America	46	100	21	66	140	38
Latin America	65	88	9.4	130	160	20
Asia	550	760	62	910	1 200	110
Europe	100	240	47	120	280	81
Oceania	4.0	7.7	1.4	6.5	12	2.9
USSR	60	110	14	82	160	31

relating to the year 1960, which is not far distant in the future, are perhaps of relatively greatest interest. Table 18 shows continental and world totals, by 5-year age groups, estimated for 1960, according to medium assumptions, while table 19 presents the same figures as percentages of the total populations of each continent and the world. It is worthy of note that while in Europe children aged under 5 are less numerous than in Africa, and hardly more numerous than in Latin America, more Europeans than Asians are aged 70 years and over (the totals are 25 and 23 millions, respectively).

One way of illustrating the problems resulting from age structure is to indicate the relative burdens of non-earning dependents per 100 persons of working ages. Conditions governing the upbringing of children, the entry of young persons into gainful employment, and the role of the aged in society vary immensely

TABLE 18. ESTIMATED NUMBERS OF PERSONS IN 5-YEAR AGE GROUPS IN EACH CONTINENT AND THE WORLD, IN 1960 (MEDIUM ASSUMPTIONS), IN MILLIONS

Age group	World	Africa	Northern America	Latin America	Asia	Europe	Oceania	USSR
0– 4	410	38	19	32	260	36	1.8	24
5– 9	350	31	18	27	210	36	1.7	22
10–14	310	27	18	24	180	36	1.6	21
15–19	280	24	16	20	160	34	1.4	20
20–24	250	21	13	18	150	29	1.1	19
25–29	220	18	12	15	130	28	1.0	17
30–34	200	16	13	13	110	30	1.1	16
35–39	180	14	13	11	95	30	1.1	15
40–44	160	11	13	10	81	29	1.0	13
45–49	140	9.5	12	8.7	67	27	0.95	11
50–54	120	7.6	11	7.3	54	25	0.86	9.8
55–59	96	5.9	10	6.0	43	22	0.77	8.4
60–64	76	4.4	8.8	4.8	32	19	0.65	6.8
65–69	56	3.0	7.2	3.5	22	15	0.53	5.1
70–74	38	1.8	5.4	2.3	13	11	0.39	3.6
75–79	22	0.88	3.6	1.3	6.7	7.5	0.25	2.3
80–84	11	0.33	1.9	0.61	2.6	4.1	0.14	1.2
85 and over	4.3	0.08	0.87	0.22	0.74	1.8	0.06	0.51
TOTAL	2 900	230	200	210	1 600	420	16	220

TABLE 19. PERCENTAGE COMPOSITION OF CONTINENTAL AND WORLD POPULATIONS BY 5-YEAR AGE GROUPS, ESTIMATED FOR 1960 (MEDIUM ASSUMPTION)

Age group	*World*	*Africa*	*Northern America*	*Latin America*	*Asia*	*Europe*	*Oceania*	*USSR*
0– 4	14.1	16.3	9.5	15.8	16.1	8.5	10.8	11.2
5– 9	11.9	13.1	9.4	13.2	12.9	8.6	10.2	10.1
10–14	10.7	11.6	9.4	11.4	11.4	8.6	9.8	9.5
15–19	9.6	10.3	8.3	9.9	10.2	8.0	8.6	9.2
20–24	8.5	9.1	6.4	8.5	9.0	6.9	6.9	8.7
25–29	7.5	7.9	5.9	7.3	7.9	6.7	6.2	8.1
30–34	6.9	6.8	6.5	6.4	6.8	7.1	6.5	7.5
35–39	6.2	5.8	6.8	5.6	5.9	7.2	6.5	6.8
40–44	5.4	4.9	6.6	4.9	5.0	6.9	6.2	6.0
45–49	4.7	4.0	6.2	4.2	4.1	6.4	5.8	5.3
50–54	4.0	3.3	5.8	3.6	3.4	5.9	5.3	4.6
55–59	3.3	2.5	5.2	2.9	2.6	5.3	4.7	3.9
60–64	2.6	1.9	4.5	2.3	1.9	4.5	4.0	3.1
65–69	1.9	1.3	3.7	1.7	1.3	3.6	3.2	2.4
70–74	1.3	0.8	2.7	1.1	0.8	2.7	2.4	1.7
75–79	0.8	0.4	1.8	0.6	0.4	1.8	1.5	1.1
80–84	0.4	0.1	1.0	0.3	0.2	1.0	0.8	0.5
85 and over	0.1	0.0	0.4	0.1	0.0	0.4	0.4	0.2
TOTAL ...	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

among the different parts of the world. The division of the population into three groups, namely children aged 0-14, adults aged 15-59, and aged persons aged 60 and over, though permitting of a common objective measure, is admittedly arbitrary. Table 20 shows dependency burdens, estimated in these terms, borne by the working populations of each continent, in 1950, 1960, and 1975, according to medium assumptions.

For diverse reasons, dependency burdens are likely to rise in most areas of the world. In parts of Africa, Latin America and Asia, the decline in mortality, particularly in early childhood and at advanced ages, leads to a proportionately greater number of survivors in childhood and old age relatively to persons of middle age. In Northern America, Europe and Oceania, because of fertility declines in the more distant past, the segment of aged persons continues to rise relatively to other segments in the population. The recent rise in fertility, furthermore, now increases the burden of child dependency in Northern America. The detailed structure of the Soviet population is less well known, but it seems likely that for some time in the future dependency burdens will decline: a recent drop in fertility probably has reduced child dependency without, for the time being, leading to a sharp rise in the dependency of old age.

TABLE 20. ESTIMATED NUMBERS OF PERSONS AGED UNDER 15, AND 60 AND OVER, RESPECTIVELY, PER 100 PERSONS AGED 15-59 IN EACH CONTINENT AND THE WORLD, 1950-1975 (MEDIUM ASSUMPTIONS)

	Persons of given ages per 100 individuals aged 15-59 years								
	1950			*1960*			*1975*		
Continent	*15*	*60 and over*	*Sum of both*	*Under 15*	*60 and over*	*Sum of both*	*Under 15*	*60 and over*	*Sum of both*
World	64	12	76	65	13	78	69	14	83
Africa	75	8	83	75	8	83	77	8	85
Northern America	45	21	66	49	24	73	49	28	77
Latin America	74	11	85	76	12	88	80	12	92
Asia	73	8	81	74	9	83	77	10	87
Europe	42	19	61	42	23	65	41	29	70
Oceania	51	19	70	55	22	77	56	25	81
USSR	56	13	69	51	15	66	51	19	70

Chapter IV

THEORETICAL AND PRACTICAL USES OF TRANSITIONAL POPULATION MODELS

Introduction

The population models employed in this report are an over-simplification of facts. But so are all demographic schemes and, in fact, any conceptual framework in the social sciences.[1]

Many a critic questions the utility of theoretical schemes whose precise conformity with facts cannot be expected. Such criticism strikes at the heart of the social sciences, and points up their difference from a science like physics. The behaviour of physical phenomena can be predicted with high precision when the number of forces with significant impact is small enough to permit their comprehensive inclusion in a pertinent calculation. The number of factors which affect social phenomena, however, is so great that to isolate them all and take each into account exceeds the powers of the intellect.[2] Although it is true that population changes occur in direct response to three factors only — births, deaths and migration — these factors, in turn, respond to a host of economic, social and cultural circumstances if not, at times, to sheer unaccountable human whim.

Much that can be said seemingly discredits the use of demographic models, but the fact remains that they are inherently true. If the factors selected as variables are the only significant ones, and the assumptions concerning them are correct, population can change in no other manner than that calculated in the model. Limited in this way, the models still serve the purposes of estimation : rational expectations can be formulated, at any time, only in terms of what is known and believed to be important. And the very shortcomings of the models are instrumental to the advancement of theory : as future events deviate from expectations, reference to the models on which expectations were based makes it possible to identify the " reasons for being surprised ".

In this way, models become a stepping stone in scientific progress. With a few factors well accounted for, attention can be directed to the more precise study of other factors whose functioning would else remain obscure.

[1] It is known that population projections made in the 1930s have been betrayed by unexpected rises in birth rates during the 1940s and 1950s. It is also known that the illustrative example of Malthus, in which population tends to increase in different proportion than the food supply, has not been borne out by facts.

[2] Economists have come to define as " functional " any function which is determined by an infinite number of variables, only some of which can be explicitly accounted for.

Rationale of the present models

The primary purpose in constructing the present models has been to project total population figures for large regions of the world. Other uses, such as the derivation of birth rates, death rates and age structures, are incidental. In deciding on the type of model to be used, a compromise was struck between the needed simplicity and the desired approximation to actual facts.

Simplicity was required for three reasons. First, the computational labour involved in model building is considerable and had to be minimized. Secondly, the knowledge of factors affecting population trends is insufficient and vital trends in some parts of the world are not well enough known to warrant the use of more elaborate schemes. Finally, simple models lead more directly to theoretical conclusions.

The degree of approximation usually desired in population projections for individual countries could not be attained, nor was it sought. But other factors were relied upon to compensate for the loss of accuracy caused by inevitable over-simplification. Among these, the following may be mentioned.

1. In projecting total numbers of actual populations, adjustments were applied to remove discrepancies between rates of growth as calculated in the models and those appearing from statistical observations. The vitiating effects of complicating factors not introduced into the models, such as migration, were thought to be partly offset in this manner.

2. The validity of the models is thought to be enhanced through geographic aggregation. The conditions governing population growth are diverse and fluctuating in particular areas, but some of this variety and irregularity disappears when large regions are treated as a whole. Some compensation of errors, furthermore, probably results when regional estimates are added together into continental and world totals.[3]

3. The models gain in their practical and theoretical value particularly from the fact that estimates are built up age group by age group. Trends in fertility, mortality and migration each have their special impact on particular age groups, and the study of resulting

[3] The reverse of this principle is also operative. Estimates for individual countries deduced from regional estimates by means of the ratio method are of low reliability because trends in particular countries are more complex and less regular than those of an entire region, and less conformity with the simple calculations is to be expected.

structural changes, itself, has practical utility. Furthermore, because of aggregation, relative errors in estimated totals are smaller than those in estimated numbers for each separate age group. The net effects of fertility and mortality themselves vary as age composition changes, and there is no better way of assessing resulting changes in total population than through calculations made separately for each age segment.

The assumptions

The models show what changes in total population and numbers in each age group are produced by assumed trends in mortality and fertility.[4] Since a " stable " population has been taken as the origin of all of the model populations, the cumulative mortality and fertility assumptions alone define each model.[5]

Specific assumptions have been worked out by a process of reasoning outlined partly in chapter I and partly in the appendix " Note ". The procedure comprises general reflections on the trends and changes in mortality and fertility typically observed so far or whose future occurrence can reasonably be expected.[6] The considerable inertia of such trends in the past supports a view that expectations can be formed in this way at least for limited time periods, such as 25 years. The particular levels of mortality and fertility selected for models were tested by the evidence of statistics on actual populations and were found to approximate to conditions in several regions. In some other regions, observed conditions could be assimilated with the average of two different models. Resemblance of conditions in the models to those actually observed during the past 25 years was regarded as a good test, even though trends in earlier periods may have been quite dissimilar.

The specific assumptions regarding population changes were :

1. Various assumed changes cause transformations in the course of time, from one initial stable population with a constant gross reproduction rate equal to 3, and a constant expectation of life of 30 years.[7] All other models can be traced back to this initial model.

2. Fertility is unambiguously defined by a characteristic combination of age-specific birth rates empirically determined for each given level of the gross reproduction rate.

3. Unless it is constant, fertility changes in a characteristic time-sequence, such as by a continuous annual decline of 0.03 in the gross reproduction rate if this is greater than 1.5, and in different manner if it is lower; these assumptions conform to average observations on actual past trends of certain populations.

4. Mortality is unambiguously defined by a characteristic combination of age-specific death rates empirically determined for each given level of the expectation of life at birth.[8]

5. Unless it is constant, mortality also declines in a characteristic time-sequence, such as by a continuous annual increment in the expectation of life by a half year, and different increments when the expectation is higher. The assumed rises in life expectancy appear normal at this time in view of observations made for successive decades prior to 1950.

The following additional assumptions are also implicit :

6. No abrupt changes in mortality or fertility will occur.

7. Migration will continue to be an insignificant factor.

8. Patterns already observed in some populations will recur in others in the future.

These implicit assumptions are not supported by observations but they are necessary if expectations are to be formulated rationally. Abrupt changes in vital trends occur in unusual situations which are beyond the purview of prediction. Migrations of considerable impact may come into play only under circumstances which cannot be foreseen. And a renewed rise in mortality (rather than a decrease of fertility) may eventually inhibit further population growth in some areas of the world, contrary to observations made so far; such an increase in mortality, however, will be resisted with every possible means unless the circumstances are catastrophic or attitudes towards human life change radically from those now accepted anywhere in the world.

Since, in what follows, frequent reference will be made to each of the several models, the chart already introduced in chapter I is presented once more, with the omission of a few population types of minor theoretical interest.[9] As before, the models will be cited in terms of the letters shown in chart VI.

Families of theoretical populations

From a theoretical viewpoint, the following types of populations can now be distinguished :

1. Stable populations (lines *AB* and *BC* on chart VI, both structurally identical). In these populations, mor-

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[4] Migration also affects age structure, though not to the same extent in large populations. For entire regions, omission of this factor can cause only small errors in calculated age structure.

[5] As has been demonstrated by Lotka, any population, regardless of its initial structure, subjected for a long period to constant rates of mortality and fertility eventually assumes a structure which is a direct function of the mortality and fertility conditions only. Such a population is known as a stable population. A. J. Lotka, *Théorie analytique des associations biologiques. Deuxième partie, Analyse démographique*, Paris, 1939.

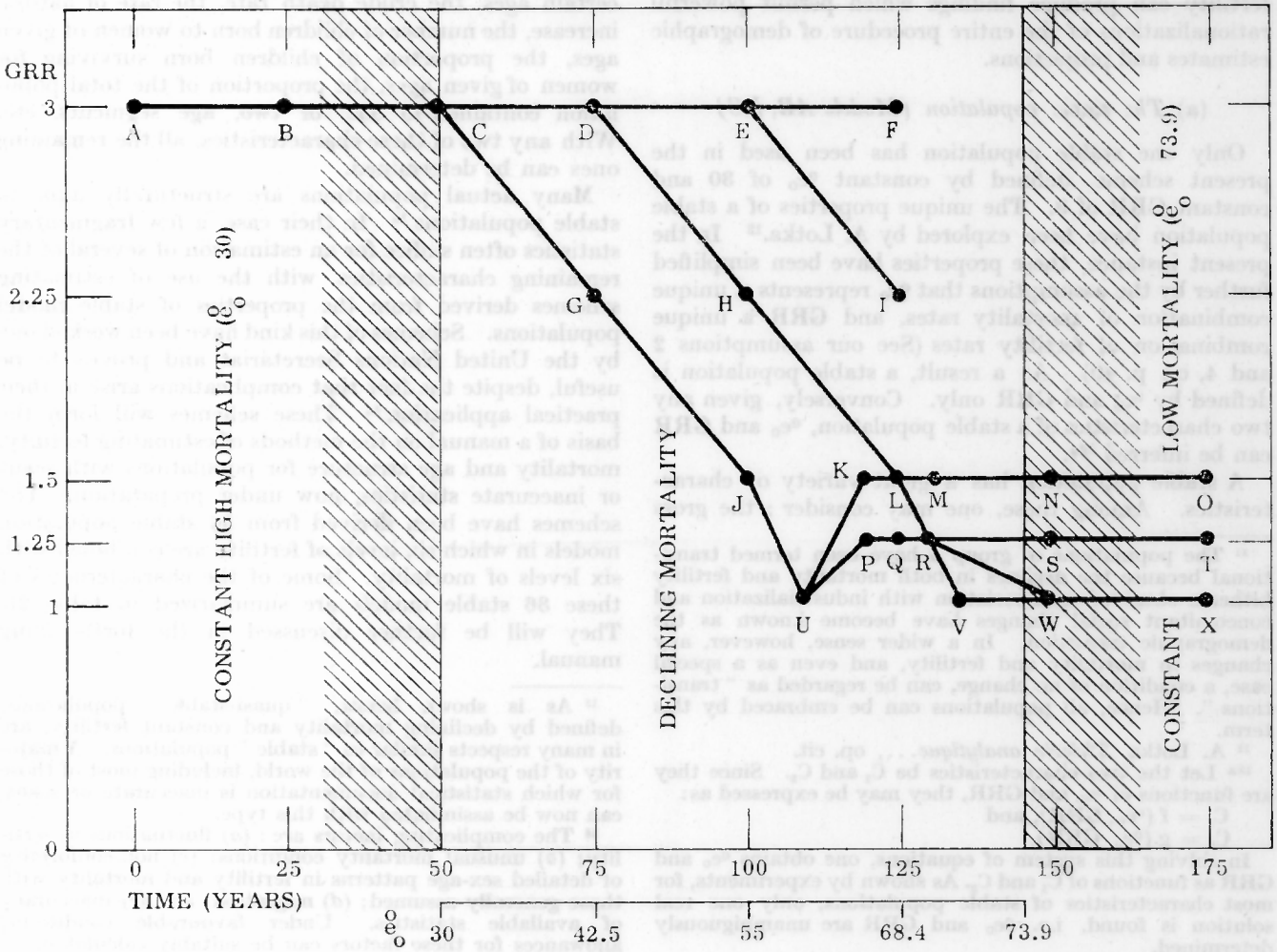
[6] Reasonable expectations can be formulated at any time only in terms of observations already made.

[7] These have probably been the approximate conditions of many populations before the modern period, and of some until quite recently.

[8] According to model life tables. See : *Methods of Estimating Population. Manual III : Methods for Population Projections by Sex and Age*, United Nations publication, Sales No. : 1956.XIII.3.

[9] The omitted models involve certain alternative future assumptions for populations of moderate or low fertility, namely *MS*, *NT*, *SO* and *SX*. The models considered here are reproduced in detail in the tables of appendix B.

CHART VI. SYSTEM OF THEORETICAL POPULATION MODELS



tality and fertility are both constant over an indefinite period of time.

2. Quasi-stable populations (lines *CD*, *DE* and *EF*). In these, mortality declines while fertility remains constant.

3. Transitional populations (lines *CG*, *DH*, *EI*, *GJ* and *HL*). Here, mortality as well as fertility decline.

4. The phase of repressed growth (*JUKL*, or *JUPQ*). In these populations, fertility drops to a minimum and then recovers somewhat, while mortality attains low levels.

5. Stabilizing populations (*LMN* and *NO*; *LRS* or *QRS* and *ST*; and *LRVW* or *QRW* and *WX*), where mortality is very low and fertility settles at a moderate, low, or very low level. The stabilizing populations differ in respect of past conditions: fertility may have declined recently (passing through *HL*) or earlier, with a subsequent phase of repressed growth (*GJ*, followed by *JUKL* or *JUPQ*.)

Under each type, an infinite number of populations can be conceived, of which only a few special cases have here been calculated. Of the five families of populations, only the first is a pure type; all the subsequent types supplant a previous one after some break of continuity in trends. Nevertheless, these selected models merit closer examination, since important properties can be discerned for populations of each of the five "families".[10]

In addition to particular theoretical conclusions, a broader generalization is also possible. In a wide sense,

[10] An attempt to develop several distinct pure types of theoretical populations was made by Winkler. Aside from the stable populations, other models were constructed in which changing functions of mortality, fertility, or both are operative over indefinite time periods, these changes corresponding to functions which remain at all times finite and positive. W. Winkler, "Age distribution and its interrelation with the elements of natural increase", in *The Proceedings of the International Statistical Conference*, 25th Session, September 6–18, 1947, Washington, D.C., Vol. III, pages 684–702; and *Typenlehre der Demographie*, Wien, 1952.

all populations are transitional.[11] An examination of diverse models of populations resulting from continuous or discontinuous changes in the levels of mortality and fertility can produce findings which permit powerful rationalizations of the entire procedure of demographic estimates and projections.

(a) *The stable population (Models AB, BC)*

Only one stable population has been used in the present scheme, defined by constant $^{o}e_{0}$ of 30 and constant GRR of 3. The unique properties of a stable population have been explored by A. Lotka.[12] In the present instance, these properties have been simplified further by the assumptions that $^{o}e_{0}$ represents a unique combination of mortality rates, and GRR a unique combination of fertility rates (See our assumptions 2 and 4, on p. 40). As a result, a stable population is defined by $^{o}e_{0}$ and GRR only. Conversely, given any two characteristics of a stable population, $^{o}e_{0}$ and GRR can be inferred [12a].

A stable population has a great variety of characteristics. Among these, one may consider : the gross reproduction rate, the net reproduction rate, the crude birth rate, the expectation of life at birth, the proportion of all deaths occurring to individuals of certain ages, the crude death rate, the rate of natural increase, the number of children born to women of given ages, the proportion of children born surviving for women of given ages, the proportion of the total population contained in one, or two, age segments, etc. With any two of these characteristics, all the remaining ones can be determined.

Many actual populations are structurally akin to stable populations.[13] In their case, a few fragmentary statistics often suffice for an estimation of several of the remaining characteristics, with the use of estimating schemes derived from the properties of stable model populations. Schemes of this kind have been worked out by the United Nations Secretariat and proved to be useful, despite the fact that complications arise in their practical application.[14] These schemes will form the basis of a manual on the methods of estimating fertility, mortality and age structure for populations with scant or inaccurate statistics, now under preparation. The schemes have been derived from 36 stable population models in which six levels of fertility are combined with six levels of mortality. Some of the characteristics of these 36 stable models are summarized in table 21. They will be further discussed in the forthcoming manual.

[11] The populations of group 3 have been termed transitional because the declines in both mortality and fertility hitherto observed in association with industrialization and concomitant social changes have become known as the demographic transition. In a wider sense, however, any changes in mortality and fertility, and even as a special case, a condition of no change, can be regarded as " transitions ". Hence, all populations can be embraced by this term.

[12] A. Lotka, *Théorie analytique...*, op. cit.

[12a] Let the two characteristics be C_1 and C_2. Since they are functions of $^{o}e_{0}$ and GRR, they may be expressed as:

$C_1 = f(^{o}e_{0}, GRR)$, and

$C_2 = g(^{o}e_{0}, GRR)$.

In solving this system of equations, one obtains $^{o}e_{0}$ and GRR as functions of C_1 and C_2. As shown by experiments, for most characteristics of stable populations, only one real solution is found, i.e. $^{o}e_{0}$ and GRR are unambiguously determined.

[13] As is shown below, " quasi-stable " populations, defined by declining mortality and constant fertility, are in many respects similar to " stable " populations. A majority of the populations of the world, including most of those for which statistical documentation is inaccurate or scant, can now be assimilated with this type.

[14] The complicating factors are : (*a*) fluctuations in fertility; (*b*) unusual mortality conditions; (*c*) non-conformity of detailed sex-age patterns in fertility and mortality with those generally assumed; (*d*) migration; and (*e*) inaccuracy of available statistics. Under favourable conditions, allowances for these factors can be suitably calculated.

TABLE 21. CHARACTERISTICS OF TYPICAL STABLE POPULATIONS WITH DIFFERENT LEVELS OF MORTALITY AND FERTILITY.

GRR	$^{o}e_{0}$	*Per cent of population aged*				*Crude rates per 1,000 population*		
		Under 15	*15-59*	*60 or more*	*All ages*	*Birth rate*	*Death rate*	*Natural increase*
4	20	45.2	52.4	2.4	100.0	63.8	53.0	10.8
3		38.5	57.6	3.9	100.0	50.5	50.2	0.3
2.5		34.1	60.7	5.2	100.0	42.8	49.1	— 6.3
2		28.9	64.0	7.1	100.0	34.2	48.6	— 14.4
1.5		22.6	66.9	10.5	100.0	24.8	49.7	— 24.9
1		14.8	68.3	16.9	100.0	14.6	54.4	— 39.8
4	30	48.2	49.2	2.6	100.0	59.8	35.3	24.5
3		41.3	54.6	4.1	100.0	47.7	33.7	14.0
2.5		36.9	57.6	5.5	100.0	40.6	33.2	7.4
2		31.4	60.9	7.7	100.0	32.7	33.6	— 0.9
1.5		24.7	63.8	11.5	100.0	23.8	35.0	— 11.2
1		16.3	65.0	18.7	100.0	14.0	39.9	— 25.9
4	40	50.0	47.3	2.7	100.0	57.3	24.1	33.2
3		43.1	52.5	4.4	100.0	46.0	23.3	22.7
2.5		38.5	55.6	5.9	100.0	39.3	23.2	16.1
2		32.9	58.8	8.3	100.0	31.7	23.7	8.0
1.5		25.9	61.6	12.5	100.0	23.1	25.6	— 2.5
1		17.0	62.6	20.4	100.0	13.6	30.9	— 17.3

TABLE 21. CHARACTERISTICS OF TYPICAL STABLE POPULATIONS WITH DIFFERENT LEVELS OF MORTALITY AND FERTILITY *(continued)*.

GRR	$^{o}e_{o}$	Per cent of population aged: Under 5	15-59	60 or more	All ages	Crude rates per 1,000 population: Birth rate	Death rate	Natural increase
4	50	51.5	45.8	2.7	100.0	55.7	16.2	39.5
3		44.6	50.9	4.5	100.0	44.9	15.8	29.1
2.5		40.0	53.9	6.1	100.0	38.4	16.0	22.4
2		34.2	57.2	8.6	100.0	31.1	16.8	14.3
1.5		27.0	60.0	13.0	100.0	22.7	18.8	3.9
1		17.8	60.7	21.5	100.0	13.4	24.3	— 10.9
4	60.4	52.9	44.4	2.7	100.0	54.1	9.4	44.7
3		46.0	49.6	4.4	100.0	43.8	9.6	34.2
2.5		41.4	52.6	6.0	100.0	37.7	10.1	27.6
2		35.6	55.8	8.6	100.0	30.6	11.1	19.5
1.5		28.2	58.7	13.1	100.0	22.5	13.5	9.0
1		18.7	59.4	21.9	100.0	13.3	19.0	— 5.7
4	70.2	54.1	43.3	2.6	100.0	52.7	4.1	48.6
3		47.3	48.4	4.3	100.0	42.9	4.8	38.1
2.5		42.7	51.4	5.9	100.0	37.0	5.5	31.5
2		36.8	54.7	8.5	100.0	30.1	6.8	23.3
1.5		29.3	57.7	13.0	100.0	22.3	9.4	12.9
1		19.5	58.6	21.9	100.0	13.3	15.1	— 1.8

(b) *The quasi-stable population (Models CD, DE, EF)*

Populations with constant fertility and declining mortality have been worked out for one level of fertility only (gross reproduction rate of 3). Mortality, after having been constant, is assumed to decline so that expectation of life rises at pre-determined rates from 30 to 68.2 years, during a period of 75 years. Other populations of this type can be imagined, but experimental calculations have shown that all such populations have generally the same properties. A summary of the salient features of the quasi-stable populations used here appears in table 22.

TABLE 22. EFFECTS OF MORTALITY DECLINE ON AGE STRUCTURE AND VITAL RATES IN A POPULATION WITH CONSTANT FERTILITY

Demographic situation	t	$^{o}e_{o}$	GRR	Per cent of total population in age groups: 0-14	15-59	60 and over	Vital rates (per 1,000): Births	Deaths	Natural increase
C	50	30	3	40.7	55.0	4.3	47.0	33.2	13.8
	55	32.5	3	40.8	54.9	4.3	46.4	30.6	15.8
	60	35	3	41.1	54.5	4.4	46.0	28.0	18.0
	65	37.5	3	41.6	53.9	4.5	45.4	25.5	19.9
	70	40	3	42.0	53.4	4.6	44.8	23.2	21.6
D	75	42.5	3	42.2	53.0	4.8	44.3	21.2	23.1
	80	45.0	3	42.5	52.6	4.9	44.0	19.3	24.7
	85	47.5	3	42.8	52.2	5.0	43.8	17.6	26.2
	90	50	3	43.2	51.7	5.1	43.5	15.9	27.6
	95	52.5	3	43.6	51.2	5.2	43.2	14.4	28.8
E	100	55	3	43.9	50.9	5.2	43.0	12.8	30.2
	105	57.6	3	44.3	50.5	5.2	42.8	11.4	31.4
	110	60.4	3	44.7	50.1	5.2	42.6	9.8	32.8
	115	63.2	3	45.1	49.8	5.1	42.4	8.4	34.0
	120	65.8	3	45.5	49.4	5.1	42.1	7.0	35.1
F	125	68.2	3	45.9	49.1	5.0	41.8	5.6	36.2

The properties of such populations are of special interest because the mortality and fertility conditions are approximately those of a majority of the world's population, in particular, the populations of large parts of Africa, Latin America and Asia. In many parts of the world, mortality is declining mainly as a result of improvements in sanitation and the control of epidemics, while fertility, so far at least, remains little affected by social and economic change.

The figures in the first and last rows of table 22 bring out the salient facts. While expectation of life more than doubles, the crude death rate declines by five-sixths, from 33.2 to 5.6 per 1,000. A comparatively small decline in the birth rate, from 47.0 to 41.8, is entirely the result of modifications in the age structure, since fertility remains constant. The change in age structure, however, is not very great.

The gradual changes in age structure are, for the most part, almost linear. In successive 25-year time periods, the proportion of children (aged 0-14) rises from 40.7 to 42.2, 43.9, and 45.9 per cent; in the same time intervals, the proportion of adults (aged 15-59) falls from 55.0 to 53.0, 50.9 and 49.1 per cent. The proportion of the aged, initially 4.3 per cent, rises to about 5.2 per cent when expectation of life approaches 50 years, and then changes very little.

The decline in the birth rate caused by the structural change is also nearly linear : in successive 25-year intervals, the fall is from 47.0 to 44.3, 43.0 and 41.8 per 1,000. The decline in the death rate, on the other hand, is more rapid at first than later, from 33.2 to 21.2, 12.8 and 5.6 per 1,000. Natural increase rises, at a diminishing pace, from 13.8 to 23.1, 30.4 and 36.2 per 1,000.

Two properties of quasi-stable populations deserve special attention because of their practical value for estimating purposes. First, changes in age structure and the birth rate, within periods of moderate length, are quite slight. Secondly, a quasi-stable population at any given moment is extremely similar to a stable population in which current conditions have already prevailed during long periods of the past.[15]

This second property can be illustrated by comparing some of the populations shown in table 21 with some of those in table 22. A word of caution is necessary : the comparison is not exact because a simpler fertility function was used when the stable population models were calculated, which leads to slightly different results.[16] Allowance for this difference can be made if the two populations with $^{o}e_{0} = 30$ and GRR = 3 are compared.[17] With this qualification, the comparison of the stable and quasi-stable populations with $^{o}e_{0} = 60.4$ and GRR = 3 gives the surprising result that the characteristics of the two populations are very nearly the same. This despite the fact that in the stable population, $^{o}e_{0}$ has always equalled 60.4, while in the quasi-stable population this current level has been attained only at the moment of observation, as a result of a long and continued mortality decline. The figures involved are given below.

	$^{o}e_{0} = 30$		$^{o}e_{0} = 60.4$	
	"Stable" population		"Stable" population	"Quasi-stable" population
	(Table 1)	(Table 2)	(Table 1)	(Table 2)
GRR	3	3	3	3
Per cent of population aged :				
0–14	41.3	40.7	46.0	44.7
15–59	54.6	55.0	49.6	50.1
60 and over	4.1	4.3	4.4	5.2
Crude vital rates per 1,000 :				
Birth rate	47.7	47.0	43.8	42.6
Death rate	33.7	33.2	9.6	9.8
Rate of natural increase	14.0	13.8	34.2	32.8

The first property of quasi-stable populations mentioned above — slight changes in age structure and birth rates for limited ranges of mortality — has this application : given, for an actual population of this general type, a rough conjecture of the mortality level, a fairly good estimate of fertility can be derived from some statistic on age structure; conversely, the detailed age composition can be estimated from some statistic relating to fertility.

Practical uses of the second property are manifold. Since, at any given moment, a quasi-stable population is very nearly identical with a stable population which has the same current conditions, the estimating schemes which can be derived from stable population models are directly relevant to a majority of the actual demographic situations in the world.

(c) *The transitional population (Models CG, DH, EI, GJ, HL)*

The models of simultaneously declining mortality and fertility employed in the present scheme are impure since, prior to the transition, they were at first stable (CG, GJ), if not also quasi-stable (DH, EI, HL). Actual populations with these transitional properties are rare at this time, but the models are of fundamental theoretical importance.

Since declines in both mortality and fertility have actually occurred in populations undergoing a process of industrialization, a theory of the demographic transition has been developed, though the causal processes of the phenomenon are still a matter of debate. Because of rising population pressure in other areas, there is now much concern with the question whether other

[15] This conclusion may be incorrect if very unusual mortality trends are to be considered.

[16] In the stable population models, a short-cut to calculations was obtained by relating the gross reproduction rate directly to women aged 25–29 (the central group of childbearing ages); in the quasi-stable models, age-specific fertility rates were taken into account. The difference in results is slight.

[17] According to assumptions, the quasi-stable population has been stable prior to point C (with $^{o}e_{0}$ constantly equal to 30).

populations will eventually enter on a similar path.[18] Accordingly, models of this type illustrate historic trends of some populations and provide a basis for speculation concerning some others. From a theoretical viewpoint, the models are instructive because they furnish at least one example of population growth under variable conditions of both mortality and fertility. In the present models, only a fixed mode of variation in either fertility or mortality has been allowed for, but in actual populations these vital conditions can vary in many ways and are never exactly constant.

[18] Where population threatens to outstrip resources, the only alternative to fertility decline would seem to be an eventual return to permanently high mortality; emigration, at the most, can be only a temporary relief. In the opinion of some, industrialization will again bring into play those forces which have been noted elsewhere in the past. In the view of some others, new rationalized attitudes towards procreation may emerge, under pressure, even in quite diverse social settings.

The present models make different combinations of the same trends : in some, fertility declines while mortality is still high, and in others while mortality is already somewhat lower. This makes it possible to compare several models in such a way that the separate effects of past changes in either fertility or mortality can be isolated.

The process of transition

Table 23 shows the changes in age structure and vital rates which occur to populations in which mortality and fertility decline simultaneously, at the assumed rates. It will be recalled (see chart VI) that models CG and GJ follow each other where fertility decline begins when $^{o}e_{0}$ is only 30 years; for models DH and HL, fertility decline begins when $^{o}e_{0}$ has attained 42.5; and for model EI, fertility does not decline until $^{o}e_{0}$ has risen to 55. All changes are gradual. To simplify matters, only the positions attained at time-intervals of 25 years are shown in Table 23, below.

TABLE 23. EFFECTS OF SIMULTANEOUS DECLINES IN MORTALITY AND FERTILITY ON AGE STRUCTURE AND CRUDE VITAL RATES

Demographic situation	t	$^{o}e_{0}$	GRR	Age structure (per cent of total population)			Crude vital rates (per 1,000)		
				0-14	15-59	60 and over	Births	Deaths	Natural increase
(*a*) Fertility decline starting when $^{o}e_{0}$ = 30									
C	50	30	3	40.7	55.0	4.3	47.0	33.2	13.8
G	75	42.5	2.25	37.8	57.0	5.2	35.8	20.0	15.8
J	100	55	1.5	31.3	60.9	7.8	24.8	12.4	12.4
(*b*) Fertility decline starting when $^{o}e_{0}$ = 42.5									
D	75	42.5	3	42.2	53.0	4.8	44.3	21.2	23.1
H	100	55	2.25	39.4	54.8	5.8	34.8	12.3	22.5
L	125	68.2	1.5	33.1	59.3	7.6	24.1	6.7	17.4
(*c*) Fertility decline starting when $^{o}e_{0}$ = 55									
E	100	55	3	43.9	50.9	5.2	43.0	12.8	30.2
I	125	68.2	2.25	41.4	53.0	5.6	34.2	5.8	28.4

In the three instances, there is a decline in the proportion of children (aged 0-14), a rise in the proportion of adults (aged 15-59), and a rise in the proportion of aged persons (60 and over). As regards the latter, aging of the population cannot have its full effect since, at the most, the models describe a fertility decline lasting over a period of 50 years only. It is important to note that the structural changes in all three cases are almost strictly parallel : in the first 25-year time period, the percentage of children always declines by about 2 1/2 points, that of adults rises by about 2 points, and that of the aged by about 1/2 point; in the next 25 years (for which there are only two examples), the shift is accelerated, children declining, relatively, about 6 points, adults rising about 4 points, and aged about 2 points.

As is to be expected, birth rates and death rates in these populations both decline. In view of the underlying assumptions, the decline in birth rates is almost linear, but is slightly more rapid in populations with initially high mortality than in those where initial mortality is already lower. The decline in death rates, on the other hand, slows down in successive time periods, and it is more rapid where mortality is initially still high than where it is initially lower. As a net result, the natural increase varies in somewhat different fashion in each instance : in populations of initially high mortality, the death rate decreases at first more rapidly than the birth rate, but later less rapidly; where initial mortality is more moderate, the decrease in the birth rate outpaces that of the death rate even from the start.

One evident use of such models might be a calculation of the rate at which fertility would have to decline if, in view of anticipated decrease of mortality, the rate of population growth or of natural increase is to remain within certain bounds. For this and other purposes, the fact that the changes occurring in the

several models are nearly parallel is practically very useful: interpolations can readily be made for all situations which are intermediate between those for which the models were initially calculated.

Comparison of transitional with quasi-stable models

In the quasi-stable models, CD, DE and EF, the same mortality declines occur as in the transitional models, but fertility, instead of declining, remains constant. The effects of declining fertility, therefore, can be isolated, for identical developments in mortality, by comparing the differences between the variations from situation C to D, E and F, with those which result from changes implied in the paths C-G-J, D-H-L, or E-I. Past mortality trends are comparable for situations D and G; E, H and J; and F, I and L. The comparisons can be made after a rearrangement of the figures in tables 22 and 23 as shown below in table 24.

TABLE 24. EFFECTS OF DIFFERENT FERTILITY TRENDS ON THE AGE STRUCTURE AND VITAL RATES OF POPULATIONS WHOSE MORTALITY TRENDS HAVE BEEN IDENTICAL

Demographic situation	t	$^{o}e_{o}$	GRR	Age structure (per cent of total population)			Crude vital rates (per 1,000)		
				0-14	15-59	60 and over	Births	Deaths	Natural increase
(*a*) Past decline in mortality from $^{o}e_{o}$ = 30 to $^{o}e_{o}$ = 42.5									
G	75	42.5	2.25	37.8	57.0	5.2	35.8	20.0	15.8
D	75	42.5	3	42.2	53.0	4.8	44.3	21.2	23.1
(*b*) Past decline in mortality from $^{o}e_{o}$ = 30 to $^{o}e_{o}$ = 55									
J	100	55	1.5	31.3	60.9	7.8	24.8	12.4	12.4
H	100	55	2.25	39.4	54.8	5.8	34.8	12.3	22.5
E	100	55	3	43.9	50.2	5.2	43.0	12.8	30.2
(*c*) Past decline in mortality from $^{o}e_{o}$ = 30 to $^{o}e_{o}$ = 68.2									
E	125	68.2	1.5	33.1	59.3	7.6	24.1	6.7	17.4
I	125	68.2	2.25	41.4	53.0	5.6	34.2	5.8	28.4
F	125	68.2	3	45.9	49.1	5.0	41.8	5.6	36.2

In populations where fertility has declined there are proportionately fewer children and more adults than in those where fertility has remained high; the full effect on the aged segment cannot be judged unless fertility decline is calculated over a much longer period. Populations where fertility has declined have considerably lower birth rates but, because of structural changes, they have also slightly different death rates (lower when general mortality is still high, but higher when general mortality is low). An important observation is the extent to which the rate of natural increase, which rises as mortality declines, is held down by the reduction in fertility. Viewed in this perspective, the several phenomena again are approximately parallel, permitting interpolations for intermediate conditions. Thus one may infer, somewhat roughly, what the effects would be if fertility declines began at various points in the time-sequence of decreasing mortality.

Comparison of transitional models inter se

The comparison of transitional and quasi-stable models in table 24 brings out the effects of different fertility trends while mortality trends were the same. Another rearrangement of figures, presented in table 25, below, permits a comparison of the effects of different mortality trends while fertility trends have been identical.

TABLE 25. EFFECTS OF DIFFERENT MORTALITY TRENDS ON THE AGE STRUCTURE AND VITAL RATES OF POPULATIONS WHOSE FERTILITY TRENDS HAVE BEEN IDENTICAL

Demographic situation	t	$^{o}e_{o}$	GRR	Age structure (per cent of total population)			Crude vital rates (per 1,000)		
				0-14	15-59	60 and over	Births	Deaths	Natural increase
(*a*) No past decline in fertility									
C	50	30	3	40.7	55.0	4.3	47.0	33.2	13.8
D	75	42.5	3	42.2	53.0	4.8	44.3	21.2	23.1
E	100	55	3	43.9	50.9	5.2	43.0	12.8	30.2
F	125	68.2	3	45.9	49.1	5.0	41.8	5.6	36.2
(*b*) Past decline in fertility from GRR = 3 to GRR = 2.25									
G	75	42.5	2.25	37.8	57.0	5.2	35.8	20.0	15.8
H	100	55	2.25	39.4	54.8	5.8	34.8	12.3	22.5
I	125	68.2	2.25	41.4	53.0	5.6	34.2	5.8	28.4
(*c*) Past decline in fertility from GRR = 3 to GRR = 1.5									
J	100	55	1.5	31.3	60.9	7.8	24.8	12.4	12.4
L	125	68.2	1.5	33.1	59.3	7.6	24.1	6.7	17.4

The comparisons show, for populations with identical fertility history but greatly differing mortality histories, very nearly the same age compositions and birth rates. The similarities are striking in view of the contrasts which were noted in table 24. In particular, such variations as are observed in table 25 are, for the most part, very nearly linear and very nearly parallel to each other. Once again it is clear that only a very rough estimate of mortality suffices to permit a fair estimate of fertility trends from data on age structure, or a fair estimate of age structure from statistics on fertility. And once again it is evident that interpolations can be made.

Since interpolations can be made in respect of both mortality and fertility, all transitional situations of the given type can be readily inferred from this general system. Thus one may plot on a chart, with mortality as the one axis and fertility as the other, the corresponding crude birth rates and crude death rates, or some other selected population characteristics. Provided the general assumptions of the system are approximately valid, the procedure of a population projection is greatly simplified. The growth in total population can be inferred quickly from the natural increase according to interpolated vital rates. Changes in age structure can likewise be assessed through interpolation among the calculated models.[19]

Comparison of transitional and stable models

To every transitional situation at any moment of time there corresponds a stable situation which would ultimately be obtained if current conditions were to continue indefinitely. The comparison of these two aspects in a population is as useful as is the distinction in physical science between acceleration with its disequilibrating effects and a constant velocity at which a body is at rest.[20] Such a comparison provides a measure of the extent to which changes in mortality and fertility distort the inherent structure of a population.

[19] The stable population models, presented in table 21, have been exploited for such estimating frameworks with application to actual populations approximating the quasi-stable type (this is the subject of the forthcoming manual already mentioned). The general principle of such systems can be greatly expanded, as is suggested in the concluding section of this chapter.

[20] A third momentum is added by changes in the rates of decline (or increase) of mortality and fertility. The concept of transitional populations can be widened accordingly.

TABLE 26. COMPARISON OF AGE STRUCTURES IN SELECTED TRANSITIONAL POPULATIONS WITH THOSE WHICH WOULD ULTIMATELY RESULT IN A STABLE POPULATION IN WHICH CURRENT CONDITIONS ARE MAINTAINED CONSTANTLY [a]

GRR	$^{o}e_{o}$	Situation	Percentage of total population in each broad age group					
			Transitional population			Stable populations		
			0-14	15-59	60	0-14	15-59	60
3	30	C [b]	40.7	55.0	4.3	41.3	54.6	4.1
	40	D [c]	42.0	53.4	4.6	43.1	52.5	4.4
	50	E [c]	43.2	51.7	5.1	44.6	50.9	4.5
	60.4	F [c]	44.7	50.1	5.2	46.0	49.6	4.4
2.5	38.3	(CG) [d]	39.2	56.0	4.8	38.2	56.0	5.8
	50.8	(DH) [d]	40.8	53.8	5.4	40.1	53.8	6.1
	64.1	(EI) [d]	42.7	51.9	5.4	41.8	52.2	6.0
2	46.7	(GJ) [d]	36.0	58.1	5.9	33.7	57.7	8.6
	59.5	(HL) [d]	37.7	56.2	6.1	35.5	55.9	8.6
1.5	55	J	31.3	60.9	7.8	27.6	59.4	13.0
	68.2	L	33.1	59.3	7.6	29.1	57.9	13.0

[a] Because of a different method of calculation, the stable populations are not precisely comparable with the transitional models, but the differences are only slight.
[b] Stable model, showing the effect of the two different methods of computation.
[c] Quasi-stable model.
[d] Interpolations in the given sequence of transitional models.

This type of comparison is made in table 26, which shows the age structures of models at various phases of the transition, as compared with the stable structures implicit in a continuation of the momentary mortality and fertility levels.[21]

In the first set of figures of table 26 (with GRR = 3), the comparison is between quasi-stable and stable models and shows the great similarity of the two. For the remaining transitional models, in which fertility has declined to some lower level, a difference from the stable models will be noted. This difference increases progressively the further fertility declines, while mortality trends and levels have comparatively little effect on it. Thus, the percentage of children is about 1 point greater than in the stable populations where GRR has fallen to 2.5, about 2 points greater where GRR has dropped to 2, and about 3 1/2 or 4 points greater

[21] The " transitional " populations, some of them interpolated, are those of table 25. The " stable " populations, some of them interpolated, belong to the scheme presented in table 21. The two schemes are not perfectly comparable because gross reproductivity was not allocated in the same manner to reproductive age groups of the population, but the errors involved in the comparison are only slight.

TABLE 27. COMPARISON OF VITAL RATES IN SELECTED TRANSITIONAL POPULATIONS WITH THOSE WHICH WOULD ULTIMATELY RESULT IN A STABLE POPULATION IN WHICH CURRENT CONDITIONS ARE MAINTAINED CONSTANTLY [a]

			Vital rates (per 1,000)					
			Transitional populations			Stable populations		
GRR	$^{o}e_{o}$	Situation	Births	Deaths	Natural increase	Births	Deaths	Natural increase
3	30	C [b]	47.0	33.2	13.8	47.7	33.7	14.0
	40	D [c]	44.8	23.2	21.6	46.0	23.3	22.7
	50	E [d]	43.5	15.9	27.6	44.9	15.8	29.1
	60.4	F [d]	42.6	9.8	32.8	43.8	9.6	34.2
2.5	38.3	(CG) [d]	39.3	23.6	15.7	39.5	24.9	14.6
	50.8	(DH) [d]	37.8	14.9	22.9	38.3	15.5	22.8
	64.1	(EI) [d]	36.9	7.8	29.1	37.4	8.4	29.0
2	46.7	(GJ) [d]	32.1	17.0	15.1	31.3	19.1	12.2
	59.5	(HL) [d]	31.4	10.0	21.4	30.6	11.6	19.0
1.5	55	J	24.8	12.4	12.4	22.6	16.3	6.3
	68.2	L	24.1	6.7	17.4	22.3	10.2	12.1

[a] Because of a different method of calculation, the stable populations are not precisely comparable with the transitional models, but the differences are only slight.
[b] Stable model, showing the effect of the two different methods of computation.
[c] Quasi-stable model.
[d] Interpolations in the given sequence of transitional models.

where GRR has attained 1.5. The differences in the percentage of adults are in the same direction, but are not so pronounced in the broad range of 15-59 years. The stable populations have larger proportions of aged persons, especially where fertility has fallen considerably; in the transitional models, where fertility is assumed to have declined for a limited period only, the transformation has not yet had its full effect on the aged segment of the population.

Vital rates in the two types of populations are compared in table 27. These again are closely similar in the set of models with GRR = 3, where fertility has not yet declined. In other transitional models, birth rates are slightly higher and death rates considerably lower than those of the corresponding stable populations because, as already shown, the full effects of the transition upon age structure are not yet apparent. If current conditions were to continue, the rate of natural increase would become smaller than it has under the influence of past transitional trends.

(d) *The phase of repressed growth* [22] *(Models JUKL, JUPQ)*

In countries where fertility has declined since early in the century, or even before, very low birth rates were recorded in the 1930s, followed by higher rates in more recent years. The recovery of birth rates was more substantial in some areas than others.

To take account of these changes, two simple models have been inserted in the present scheme, described by the lines JUKL and JUPQ in chart VI. The rough assumptions result in a fair approximation to certain actual conditions as can be seen from a comparison of these models with the statistical observations for Northern America, Europe and Oceania presented in appendix A.

Why this depression of birth rates, followed by partial recovery, should have occurred is still a matter of debate. There is no apparent reason to expect that a similar swing of the pendulum will recur either in the same populations or in others. The phase described by these models finds no place in any coherent body of theory, and the models need not be examined further in this chapter. The effect of this development, which has been peculiar to certain populations in the recent past, becomes apparent in an examination of the emerging stabilizing populations, the last group now to be discussed.

(e) *The stabilizing population (Models LMN, NO, LRS, QRS, ST, LRVW, QRV, WX)*

The models considered in this group are impure because they issue from assumed previous population trends of various kinds. Prior to the period of stabilization, some models have passed through the transitional phases DH and HL, and others through the phases of repressed growth, JUKL or JUPQ.[23] But

[22] A term had to be invented to define a peculiar development which has occurred in certain actual populations. This term is merely intended as a description of an observed phenomenon and has no theoretical connotation.

[23] The models inherited from the transitional phases DH and HL were originally stable and then quasi-stable (CD). Those inherited from the phase of repressed growth stem from the same initial stable model, followed by the transitional phases DG and GJ. Beyond points L and Q, many of the effects of trends in the more remote past have worn off, but those of more recent trends (phases HL, JUKL and JUPQ) continue to have considerable influence.

with time, as mortality and fertility remain constant,[24] the models are progressively purified, until they approximate the stable populations which result from the indefinite continuance of the given conditions. The models undergo precisely that process of stabilization for which Lotka has furnished a mathematical description.[25]

To arrive at theoretical conclusions, it will suffice to confine comparisons to the models which stabilize with GRR = 1.5 and GRR = 1.25.[26] In chart VI these correspond to the lines LMNO and QRST (or LRST). In each instance, however, there are two different models, depending on which trends have preceded points L and Q. To distinguish them, we shall give the name "transitional-stabilizing" to the models of recent fertility decline, whose preceding trend is described by the line HL; and "repressed-stabilizing" to those whose directly preceding trend was either JUKL or JUPQ.

[24] Some further mortality decline beyond points L and Q has actually been assumed, $^{o}e_{o}$ rising, in 20 years, from 68.2 to 73.9 and then remaining constant. The small change in mortality interferes little with the process of "stabilization" since, as has been noted, much larger reductions in mortality have but little effect on age structure and birth rates.

[25] A. Lotka, op. cit.

[26] Models LRVW, QRW and WX eventually stabilize with GRR = 1, but less rapidly than the other models. During the period for which calculations have been made, the populations grow at a low and decreasing rate. Though mortality is low, the ultimate "stable" population with GRR = 1 would be a slowly decreasing one.

TABLE 28. COMPARISON BETWEEN AGE STRUCTURES OF INITIALLY TRANSITIONAL AND REPRESSED POPULATIONS STABILIZING WITH A GROSS REPRODUCTION RATE OF 1.5

Demographic situation	*t*	$^{o}e_{o}$	*GRR*	*Per cent of total population in each age group*					
				"transitional-stabilizing" population [a]			*"repressed-stabilizing" population* [b]		
				0-14	*15-59*	*60 and over*	*0-14*	*15-59*	*60 and over*
L	125	68.2	1.5	33.1	59.3	7.6	27.3	60.3	12.4
M	130	70.2	1.5	31.7	60.0	8.3	28.7	58.1	13.2
	135	71.7	1.5	30.9	60.1	9.0	28.2	57.7	14.1
	140	73.0	1.5	30.6	59.6	9.8	27.2	57.9	14.9
	145	73.9	1.5	30.3	59.1	10.6	27.1	57.4	15.5
N	150	73.9	1.5	29.9	58.8	11.3	27.7	56.4	15.9
	155	73.9	1.5	29.5	58.5	12.0	28.4	55.6	16.0
	160	73.9	1.5	29.1	58.3	12.6	28.7	55.5	15.8
	165	73.9	1.5	29.0	57.9	13.1	28.7	56.0	15.3
	170	73.9	1.5	29.0	57.5	13.5	28.7	57.1	14.2
O	175	73.9	1.5	29.0	57.3	13.7	28.8	57.9	13.3
	...	...	...	...	...	...	...	...	...
Ultimate [c]	...	73.9	1.5	28.9	57.6	13.5	28.9	57.6	13.5

[a] Immediately preceding phase: HL.
[b] Immediately preceding phase: JUKL.
[c] After indefinite continuance of constant levels of mortality and fertility.

Comparison is made, in table 28, of changes in structure, by broad age groups, in the two types of models which stabilize with GRR = 1.5. Many changes occur within narrower age ranges, but these do not appear in the table.

In the "transitional-stabilizing" model, the proportion of children, initially 33 per cent, falls off with diminishing speed to approximate, 50 years later, the proportion of the ultimate stable population. The percentage of adults rises to a maximum of 60 per cent, and then likewise falls to near the ultimate stable figure within 50 years. There is a continuous rise in the proportion of aged persons, attaining almost the ultimate figure by the end of 50 years.

In the "repressed-stabilizing" population, on the other hand, the ultimate proportions are approximated very soon after the stabilizing process has begun.[27] Throughout the 50 years for which calculations have been made, the percentages fluctuate around the ultimate stable figures, with decreasing amplitude. Evidently, the phase of repressed growth which immediately preceded stabilization has, for the most part, wiped out the previously transitional features of the population.

[27] According to assumptions, stabilization begins already five years prior to point L (at point K on the chart). At that point, 25.2 per cent of the population are aged 0–14, 63.2 per cent 15–59, and 11.6 per cent 60 and over. The structure changes rapidly within only ten years (compare with percentages at M in table 28), and it can be said that, at this phase, the population is "growing both younger and older at the same time".

TABLE 29. COMPARISON BETWEEN AGE STRUCTURES OF INITIALLY TRANSITIONAL AND REPRESSED POPULATIONS STABILIZING WITH A GROSS REPRODUCTION RATE OF 1.25

Demographic situation	t	°e₀	GRR	Per cent of total population in each age group: "transitional-stabilizing" population [a] 0-14	15-59	60 and over	"repressed-stabilizing" population [b] 0-14	15-59	60 and over
Q (L) [c]	125	68.2	1.25 (1.5) [c]	33.1	59.3	7.6	24.7	62.5	12.8
R	130	70.2	1.25	31.1	60.5	8.4	25.5	60.6	13.9
	135	71.7	1.25	29.0	61.7	9.3	24.9	60.1	15.0
	140	73.0	1.25	27.4	62.1	10.5	24.0	59.8	16.2
	145	73.9	1.25	26.8	62.0	11.2	23.6	59.2	17.2
S	150	73.9	1.25	26.7	61.1	12.2	23.7	58.2	18.1
	155	73.9	1.25	26.2	60.7	13.1	24.1	57.2	18.7
	160	73.9	1.25	25.5	60.4	14.1	24.3	56.7	19.0
	165	73.9	1.25	24.9	60.1	15.0	24.3	56.8	18.9
	170	73.9	1.25	24.6	59.5	15.9	24.2	57.8	18.0
T	175	73.9	1.25	24.6	58.8	16.6	24.3	58.5	17.2
	...	...	...	...	...	...	...	...	...
Ultimate [d]	...	73.9	1.25	24.4	58.4	17.2	24.4	58.4	17.2

[a] Immediately preceding phase : HL.
[b] Immediately preceding phase : JUPQ.
[c] At this phase, fertility in the "transitional-stabilizing" population is still falling. The figures are attained at the terminal point of the HL-phase, where GRR is still 1.5.
[d] After indefinite continuance of constant levels of mortality and fertility.

In table 29, the same comparison is made between previously transitional and previously repressed populations stabilizing with GRR = 1.25. The conclusions are essentially the same as those made in connexion with table 28 : the "transitional-stabilizing" model approximates to its ultimate stable proportions very gradually, whereas the "repressed-stabilizing" model resembles the stable population at an early stage, with fluctuations which decrease in time.

A comparison of trends in vital rates between the two types of models stabilizing with GRR = 1.5 is presented in table 30. The progressive approximations to the ultimately stable rates in the two instances are as expected in view of observations already made on the trends in age structure.

For practical reasons, stabilizing populations are of special interest in connexion with population projections, whether their intent is predictive or illustrative.

TABLE 30. COMPARISON BETWEEN VITAL RATES OF INITIALLY TRANSITIONAL AND REPRESSED POPULATIONS STABILIZING WITH A GROSS REPRODUCTION RATE OF 1.5

Demographic situation	t	°e₀	GRR	Vital rates (per 1,000): "transitional-stabilizing" population [a] Births	Deaths	Natural increase	"repressed-stabilizing" population [b] Births	Deaths	Natural increase
L	125	68.2	1.5	24.1	6.7	17.4	22.2	9.4	12.8
M	130	70.2	1.5	24.0	6.4	17.6	20.6	9.1	11.5
	135	71.7	1.5	23.8	6.2	17.6	19.9	9.0	10.9
	140	73.0	1.5	23.3	6.2	17.1	20.2	9.8	10.4
	145	73.9	1.5	22.7	6.2	16.5	20.8	8.9	11.9
N	150	73.9	1.5	22.2	6.6	15.6	21.3	9.1	12.2
	155	73.9	1.5	22.0	7.0	15.0	21.4	9.3	12.1
	160	73.9	1.5	21.9	7.4	14.5	21.2	9.4	11.8
	165	73.9	1.5	21.8	7.6	14.2	21.2	9.2	12.0
	170	73.9	1.5	21.8	7.8	14.0	21.4	9.2	12.2
O	175	73.9	1.5	21.7	8.0	13.7	21.3	9.2	12.1
	...	...	...	...	...	...	...	...	...
Ultimate [c]	...	73.9	1.5	22.5	9.3	13.2	22.5	9.3	13.2

[a] Immediately preceding phase : HL.
[b] Immediately preceding phase : JUKL.
[c] After indefinite continuance of constant levels of mortality and fertility.

If no good reason appears for assuming future variations in mortality and fertility, the best rational prediction relies on what is already known; a stabilizing population then furnishes the most reasonable future estimates. If, on the other hand, there are reasons to assume future changes in mortality and fertility, the future estimates must reflect the effects of the assumed transition; comparison of these estimates with the corresponding stabilizing population brings to light the net effects of assumed future changes in mortality and fertility. The systematic study of properties inherent in stabilizing populations, then, will facilitate the task of arriving at certain predictive or illustrative projections rather quickly.

Conclusions

Five families of population models have been briefly surveyed. They have been found to possess properties which are directly useful in a rationalization of population estimating procedures. Except for the initially stable population, the models are impure because a break of continuity occurs at each juncture of the scheme where trends of one type give way to trends of another type. On the other hand, the scheme is comparatively simple and its assumptions are in keeping with some typical empirical observations.

The value of stable populations is fundamental. This family of models serves as a point of reference, showing the inherent structure and dynamics of any given population, abstraction being made of the distorting effects of past variations in trends. The magnitude of these distortions is measurable.

Populations of constant fertility and varying mortality have here been defined as quasi-stable because of the small effect of mortality changes on age structure. It was shown that at any moment a quasi-stable population resembles very closely the corresponding stable population. Many actual populations in the world for which statistical documentation is scanty are of the quasi-stable type, or very nearly so. The missing statistics can often be estimated with the aid of a system of stable population models.

To be more precise, in no population is mortality or fertility ever exactly constant, and in some the two factors have undergone large changes. In a wide sense of the term, every actual population is transitional. In the narrower sense used here, pre-determined rates of change in mortality and fertility have resulted in a small system of transitional populations of a special type. It has been shown that interpolations can be made and that these can have practical applications in the projection of those populations to which the rigid assumptions of the limited system are relevant.

The phase of repressed growth has not been examined in detail, as there is no evident reason to expect that trends of this type will recur. It was found, nevertheless, that a cycle of this type can rapidly annihilate most of the structural features inherited by a population from an earlier phase of transition.

Stabilizing populations, of special interest in population projections, can furnish a basis for the quick calculation of certain future estimates, once their theoretical properties have been systematically charted.

If a wide view is taken, the concept of transitional models can be expanded to embrace all types of populations that can be of practical concern. The transitional models used here depend on rigid assumptions on rates of decline in mortality and fertility. In this limited system, the uses of interpolations in a two-dimensional field are evident. But more dimensions can be added and interpolations are possible in many directions. Two additional dimensions would result from making variable the rates of decline in either mortality or fertility, permitting also their increase, as the case may be. A further variable can be introduced by a suitable scheme incorporating the demographic effects of migration. Each added variable increases the flexibility of the system, and approximations to all actual conditions can be improved accordingly.

Wherever interpolations are possible and irrespective of how many may be the dimensions with which the system is equipped, only a limited number of models need be calculated. All situations intermediate between those calculated can then be readily deduced.

Simple approximations, like those which are obtained when advantage is taken of the finding that age structure is little affected by variations in mortality, serve the purpose of arriving at some rough estimates very quickly.

Appendix A

NOTE ON THE ADEQUACY OF THE MODELS AS APPLIED TO PARTICULAR REGIONS

The demographic models which have been taken to represent approximately the structure and dynamics of the several regional populations are defined in terms of the levels and trends of general mortality [1] and general fertility.[2] Age structure, crude birth rates, crude death rates, and rates of natural increase are the resultants. In selecting the models, care has been taken to make them conform, as far as possible to actual populations, while maintaining their necessary simplicity.

The available statistics on expectation of life, gross reproduction rates, birth rates, death rates, age structure and rates of growth are of varying quality, some data being more reliable than others. Except for regions where statistics are of the highest accuracy, not much reliance can be placed on recorded birth rates and death rates. Rates of population growth inferred for periods during which at least two censuses have been taken successfully deserve greater confidence, but very often the last census interval covers part, or all, of the period of the Second World War, which often affected rates of growth and raised mortality higher than it should have been. Measures of age structure, at least in areas where there is some awareness of the importance of chronological age-reckoning, are more reliable, as there is little reason for enumerations of the population to be less complete in respect of some age groups than others. Even here, defects resulting from the omission of children and the exaggeration of old age need be recognized.

Experimental calculations show that past trends of fertility have by far the most important effects on age structure, those of past changes in mortality or of international migratory movements being generally of less consequence. Data on age structure, therefore, subject to cautious interpretation, provide a fairly good gauge for estimates of fertility. In the absence of reliable statistics on deaths, it is more difficult to arrive at reasonably reliable evaluations of the level of mortality by this indirect method. If the rate of growth of a population has been determined from two successive censuses and a fairly adequate estimate of the level of fertility can be made, the level of mortality can also be calculated, provided data are used with caution.

These and similar methods have made it possible to estimate levels of fertility and mortality and the probably true levels of crude birth rates and crude death rates for countries whose statistics on births and deaths are of doubtful accuracy, known to be inaccurate, or even non-existent. Numerous estimates of this kind have been published in the survey of world population trends which forms part of a recent Report on the World Social Situation [3] and will be referred to in the following pages. Verification of the adequacy of the population models will also be sought by comparisons of statistical records on age structure, and of other measures, with the theoretical estimates derived in the models.

1. Africa

Conditions in *Middle Africa* have been assumed to approximate to those of the model of a stable population in which, for an indefinite period of the past, gross reproduction was of the order of 3, and expectation of life was 30 years. Few statistics in Middle Africa are reliable enough to provide a good test for these assumptions, which had to be based in part on theoretical considerations. From observations in other parts of the world, it appeared unlikely that a gross reproduction rate of 3 would be much surpassed under adverse health conditions, though fertility in Middle Africa, on the whole, is probably very high. With a reproduction rate of 3, the replacement of successive generations is almost exactly ensured if the expectation of life is 20 years; thees may have been the demographic conditions in Africa, on the average of long time-periods, when predatory warfare, epidemics, and slave raids were frequent occurrences. More effective administration in modern times averts some of these causes of excessive mortality and the average expectation of life may have come to approach 30 years, even in the absence of large-scale measures of disease control.

If the model is correct, then the population of Middle Africa may have increased by 36.7 per cent in 25 years: available estimates for 1925 and 1950, many of them unreliable, suggest an increase by 30 per cent. According to the model, 40.7 per cent of the population should have been aged under 15. The following percentages have been recorded in official statistics: 36.5 (Portuguese Guinea, 1950), 39.4 (Madagascar, 1951), 40.4 (Angola, 1940), 41.0 (Belgian Congo, 1950), 42.3 (British Cameroons, 1952–53), 42.4 (Uganda, 1948), 42.9 (the Gold Coast (now Ghana), 1948), 44.3 (Nigeria, 1952–53), and 44.9 (Tanganyika, 1948). The accuracy of the statistics may be doubted, but it is possible that, at least for the period prior to 1950, the model slightly under-estimates both fertility and mortality. It would be difficult, on the other hand, to arrive at a better estimate of current and future conditions in the present state of statistical information.

For *Northern Africa* and *Southern Africa* it has been assumed that conditions approximate the average of those implied in models where the gross reproduction rate is 3, while expectation of life in 1950 is 30 years for Northern Africa, and 42.5 years for Southern Africa. The statistical

[1] According to a succession of model life tables, each of which is characterized by a given expectation of life at birth (both sexes combined).

[2] As summarized by the gross reproduction rate, usually defined as the number of daughters born to women in the course of their reproductive lives. For simplicity, no distinction by sex was made. For each gross reproduction rate, a typical pattern of age-specific fertility rates, applicable to the population of both sexes, was assumed.

[3] "World Population Trends", in *Report on the World Social Situation* (United Nations publication, Sales No.: 1957.IV.3), chap. II, pp. 5–27.

data for these two regions, although better than for Middle Africa, are nevertheless fragmentary. According to the average of the two models, population should have increased by about 48 per cent from 1925 to 1950, the current birth rate should be about 45, and the current death rate about 26, per 1,000, while 41.5 per cent of the population should be aged under 15.

From available estimates, population increase in *Northern Africa* from 1925 to 1950 may have been about 47 per cent. A birth rate of 45 was recorded for Egypt in 1951, and a rate of 41 for Moslems in Algeria in 1951–53, both of which rates are plausible since 42.5 per cent of the Algerian Moslem population were enumerated in 1953 as aged under 15, while the percentage was 42.0 for the Moslem population of Morocco in 1952, and 41.4 for the Moslem population of Tunisia in 1946. Recorded death rates, to be sure, are much lower than estimated in the model, but death registration is probably incomplete or the population would have had to grow much more rapidly in the past than has been estimated. Likewise, many children were probably omitted in the Egyptian census of 1947 when only 38.1 per cent of the population were reported as aged under 15. If credence is given to population estimates for 1925 and 1950, to birth rates recorded in Egypt and Algeria, and to census age statistics for Algeria, Morocco and Tunisia, the agreement of the model with observed facts appears to be very close.

Demographic conditions in *Southern Africa* are more complex, because of the divergent levels of fertility and mortality among the several ethnic groups. Available estimates show a 60 per cent increase in population from 1925 to 1950, but some part of this increase should be attributed to immigration. The recorded mortality of the European minority is quite low, that of the Asiatic and Coloured groups somewhat higher, but adequate vital statistics on the Bantu majority are not available. By a method tending to a conservative estimate, Badenhorst [4] has evaluated the Bantu death rate as between 21 and 25 per 1,000 prior to 1946, and it seems probable that the true death rate is near the upper limit of this range; Badenhorst's estimate of the Bantu birth rate, probably also on the conservative side, is 38 to 42 per 1,000. The birth rate of the Asiatic minority is somewhat higher and of Europeans in South Africa considerably lower. At the census of 1946, 37.8 per cent of the total population (all ethnic groups) of the Union of South Africa was found to be aged under 15, but there has probably been some under-enumeration of small children. It is possible that both fertility and mortality for this region are over-estimated in the assumed combination of models, but no other simple model could be substituted to represent the rather complex conditions of this multi-racial population.

2. Northern America

The model assumed for this population is one where expectation of life has risen from 55 years in 1925 to 68.2 years in 1950, while fertility, having declined since long before 1925, passes through a minimum in the 1930s and then rises again to a gross reproduction rate of 1.5 in 1945.

Available life tables for the United States show expectations of life (both sexes) of 56.4 around 1920, 59.3 around 1930, and 68.4 in 1950; values in the Canadian life tables are closely similar.

[4] L. T. Badenhorst, "The Future Population of the Union of South Africa and its Probable Age Distribution", *Population Studies* (London), June 1950, pp. 3–46, Badenhorst's estimates tend to be conservative since no allowance was made for immigration, nor for incomplete enumeration of children at the census.

A comparison of crude birth rates and crude death rates, 1925–1955, between the figures implied in the model and those actually observed in the United States and Canada is given below; this also shows good agreement, except that the 1950–55 birth rate in the model is an under-estimate.

Period	*Crude birth rate*			*Crude death rate*		
	Assumed in model	*Observed in*		*Assumed in model*	*Observed in*	
		U.S.A.	*Canada*		*U.S.A.*	*Canada*
1925–30	22.5	20.1	24.5	11.9	11.8	11.1
1930–35	18.6	17.6	22.2	10.9	11.0	10.0
1935–40	18.7	17.2	20.3	10.4	11.0	9.8
1940–45	22.3	19.8	21.6	10.1	10.6	9.8
1945–50	23.0	23.7	27.1	9.6	10.0	9.3
1950–55	21.3	24.6	27.0	9.2	9.5	8.6

Since the model fits past trends well, especially as regards the much larger population of the United States, the estimate of current age structure as shown below is likewise satisfactory.

Age group	*Per cent of population in each age group*		
	Model (1950)	*United States (1950 census)*	*Canada (1951 census)*
0–14	27.3	26.9	30.3
15–29	21.9	22.8	23.4
30–44	21.6	21.9	20.8
45–59	16.8	16.3	14.1
60 and over	12.4	12.2	11.4
TOTAL ...	100.0	100.0	100.0

The model is a close approximation to the mortality and fertility trends in the United States up to 1950 but tends to underestimate the birth rate after that date. Furthermore, it takes no account of the effects of migration.

3. Latin America

Demographic trends in *Central America* and *Tropical South America* are assumed to be similar to those of a model where an average expectation of life of 42.5 years is attained in 1950, while gross reproduction is constant at the rate of 3. In such a population, the theoretical birth rate in 1950–55 would be about 44, the theoretical death rate about 20, and 42.2 per cent of all individuals would be aged less than 15 in 1950. The increase in population from 1925 to 1950, in the absence of migration, should have been by 59.7 per cent.

From available estimates, it is inferred that the population of *Central America* has increased by about 65 per cent in those 25 years. According to censuses taken in 1950, the percentages aged less than 15 were: 40.6 (Honduras), 41.6 (Panama), 41.1 (El Salvador), 41.8 (Mexico), 42.3 (Guatemala), 42.8 (Costa Rica), and 43.3 (Nicaragua), but it is probable that some of the small children failed to be enumerated in each instance. A birth rate of 44.6 per thousand has been recorded in Mexico during 1950–52, probably quite reliably, while the birth rate was assessed as near 45 per 1,000 in Costa Rica, Honduras and Panama.[5] Perhaps somewhat less reliably, a death rate of 15.1 was registered in Mexico during 1950–55; independent estimates assess the death rate as near 20 in Honduras, Nicaragua and Panama, though much lower rates have been recorded in the available statistics. The model may be taken as a fairly good

[5] Here, and in the following, the assessed rates are those, estimated by demographic methods, which have been published in the *Report on the World Social Situation*, op. cit.

approximation of the fertility level, but it is possible that the mortality of this area is slightly over-estimated in the model.

The increase of the population of *Tropical South America* from 1925 to 1950 has been evaluated from the available population estimates at 67 per cent. For Brazil, which has no comprehensive national vital statistics, Mortara has estimated a birth rate of 42 to 44, and a death rate of 18 to 20, per 1,000.[6] The birth rates of Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela have been assessed independently at near 45 and the death rates at near 20, per 1,000.[7] At recent censuses, the following percentages of population aged less than 15 years have been recorded : 39.6 (Bolivia, 1950), 42.0 (Venezuela, 1951), 42.5 (Ecuador, 1950), and 43.8 (Brazil, 1950). The precision of these data and estimates is not very great, and the model is probably a good approximation to the facts of the situation, though it is possible that fertility on an average is slightly higher than in the model.

The model used for the projection of the *Caribbean* population cannot be clearly defined. Future population estimates have been calculated on an assumption that rates of growth will be lower by a constant amount than those of the model applied to the populations of Central America and Tropical South America. This pattern of growth may be approximated with a current death rate averaging, say, 18 per 1,000 and a birth rate averaging about 35 per 1,000, or more, if continued emigration is also being considered. Generalization on the demographic conditions in the several islands of this region is difficult, there being considerable variations in the levels of fertility, mortality, age structure, and the intensity of migratory movements.

Reliably recorded death rates are 11.1 for Jamaica and 8.7 for Puerto Rico (averages for 1950–55), while a death rate of about 15 has been assessed for Cuba, and about 20 for the Dominican Republic; in Haiti, the death rate is probably high, but cannot be assessed without great difficulty. Birth rates registered in 1950–52 were 33.3 in Jamaica, 36.3 in Trinidad and Tobago, and 37.6 in Puerto Rico; a rate of around 35 has been assessed for Cuba, and about 50 for the Dominican Republic; the birth rate in Haiti probably is also very high. On this evidence, the development of a separate model fitting the average conditions of the region seemed hardly justifiable. The practical device used in projecting regional population totals, nevertheless, bears some relation to the situation actually prevailing on a broad average, among the several islands.

For *Temperate South America*, it has been assumed that demographic trends approximate those of the average of two models, both of which incorporate a current expectation of life of 68.2 years and a current gross reproduction rate of 1.5. One of the two models implies a recent decline in fertility and the other an early decline in fertility, passing through a minimum in the 1930s, with subsequent recovery, as in the case of Northern America. The net effect of combining the two models is a fairly recent fertility decline, ending in the 1930s.

The model was intended primarily to approximate observed conditions in Argentina, which contains the majority of the regional population. This means that it leaves out of account the fact that both fertility and mortality are considerably higher in Chile and Paraguay, though possibly slightly lower in Uruguay. Furthermore, in recent years an addition to population in this region has resulted from a considerable volume of immigration. These qualifications are necessary before a conclusion can be drawn from the comparison between trends and structure according to the models used and as actually recorded in Argentinian statistics.

Crude birth rates and death rates assumed in the model and observed in Argentina, from 1925 to 1955, are presented below.

	Crude birth rates		*Crude death rates*	
Period	*Assumed in models*	*Observed in Argentina*	*Assumed in models*	*Observed in Argentina*
1925–30	28.2	29.9	11.8	13.0
1930–35	25.2	26.8	10.6	11.6
1935–40	24.2	24.0	9.7	11.6
1940–45	24.8	24.2	9.0	10.3
1945–50	24.1	25.0	8.4	9.5
1950–55	22.7	24.7	7.9	8.7

According to the models, 30.2 per cent of the population should have been aged less than 15 years in 1950, actually 30.9 per cent have been so enumerated in the Argentinian census of 1947. The models slightly under-estimate both fertility and mortality in Argentina. Since they do not incorporate the effects of immigration, and since both fertility and mortality in Chile and Paraguay are considerably higher, the characterization of this regional population is not very satisfactory. On the other hand, current economic and social development in parts of Tropical South America, notably in South Eastern Brazil and in Venezuela are likely to produce demographic situations in those areas more similar to those of Argentina than to the remainder of Tropical South America. When all estimates for the two parts of South America are combined, some of the errors in the regional estimates may be compensated.

4. Asia

One model has been used to represent approximately the conditions of four regions : *South-West Asia*, *Central South Asia*, *South-East Asia*, and *East Asia (without Japan)*. According to the model, the birth rate should be 46.5, and the death rate 32.0 per 1,000, in the 1950–55 period while, in 1950, 40.7 per cent of the total population would have been aged less than 15 years. From 1925 to 1950, there should have been a population increase by 36.7 per cent.

Statistics in *South-West Asia* are fragmentary and not very conclusive, except for the small population of Israel, whose trends are untypical of this region. According to available population estimates, many of them quite unreliable, the combined population of this region has increased by about 38 per cent from 1925 to 1950, an increase which agrees satisfactorily with the model. Censuses of Turkey have recorded 39.5 (in 1945) and 38.3 per cent (in 1950) of the population as aged under 15, and it is probable that birth rates were lower than usual during the Second World War and that some of the small children have not been enumerated. According to the 1947 census of Iraq, 32.2 per cent of the population were aged 5–19 years (according to the model, the percentage should have been 34.9), but this figure may have been affected by a tendency of persons aged somewhat less than a full 20 years to declare their ages as 20. In the absence of satisfactory vital statistics or reliable assessments of levels of fertility and mortality, it is difficult to determine how closely the model approximates to the reality of the situation in this area. That it is not necessarily unrealistic would seem to follow from a comparison of social conditions in South-West Asia with those in the two neighbouring regions of Northern Africa and Central South Asia respectively, but it must be admitted that there is some room

[6] Giorgio Mortara, " The Development and Structure of Brazil's Population ", *Population Studies* (London), November 1954, pp. 121-139.

[7] *Report on the World Social Situation*, op. cit.

for doubt. Comparison with the estimated growth of the population and age structures according to censuses makes it appear more likely that mortality as assessed in the model is too high, than that fertility has been assessed too low.

India contains a majority of the population of *Central South Asia*. Though Indian vital statistics are far from complete, many studies of fertility and mortality in that country have been made, utilizing the results of decennial censuses, suitably adjusted or graduated. By this method, Davis [8] has estimated a birth rate of 46.4 and a death rate of 36.3 for the 1921–1931 period, and a birth rate of 45.2 and a death rate of 31.2 for the 1931–1941 period. Using a different approach, a recent study [9] places the birth rate at 43.2 and the death rate at 31.0 for 1951. The results of these studies, obtained by the most refined demographic techniques available, are in close agreement with the model used here, except that both fertility and mortality appear to be slightly lower than in the model. For the region as a whole, however, conditions in the large population of Pakistan need also be taken into account. A comparison of census age tabulations suggests that fertility in Pakistan is somewhat higher, and an independent assessment has resulted in a birth rate near 50 for Pakistan; [10] if this is taken into account, as well as the comparative inter-censal increases of the populations of India and Pakistan, respectively, it appears that the Pakistan death rate is about two points higher than the death rate of India.[11] If allowance is made for somewhat higher levels of both fertility and mortality in Pakistan, the agreement of the model with the best independent estimates is excellent indeed. The Central South Asian region has been defined to include also Ceylon, where vital rates have been reliably recorded at considerably lower figures, but the effect of these divergent trends in Ceylon is probably offset by the further inclusion of Afghanistan, Bhutan and Nepal where it may be expected that both fertility and mortality are very high.

Statistics for the countries of South-East Asia are of widely varying quality. In particular, the demographic trends in Indonesia, which contains nearly one-half of the regional population, are largely a subject of conjecture; the official population estimates indicate that, both in the past and in recent years, an annual increase of the population by 1 1/2 per cent is regarded as " normal ". Fragmentary statistics on the age composition of the Indonesian population have led Wertheim [12] to the view that the birth rate must be higher than 40 per 1,000 if mortality is moderate, and possibly as high as 48 per 1,000, if mortality is exceedingly high. In an area of Central Java, where birth registration is believed to be comparatively accurate, rates of 42.5 and 45.2 have been recorded in 1951 and 1952. In view of the estimated rate of growth, the death rate in Indonesia may be near 30 per 1,000. Independent assessments [13] attribute birth rates near 50 per 1,000 to the Philippines and Thailand, and death rates of 31 to the Philippines and 28 to Thailand. In Malaya and Singapore, where vital registration is more accurate, average birth rates during 1950–55 were 43.6 and 47.6, while average death rates were as low as 13.4 and 10.6, per 1,000. As applied to this general region, the fertility assumed in the model may be roughly correct, but there are grounds to believe that mortality has been over-estimated. Thus, the high death rates assessed for the Philippines and Thailand are derived from inter-censal periods which include the Second World War, a time during which mortality is likely to have been higher than had more normal conditions prevailed.

The great majority of the population comprised in *East Asia (without Japan)* lives on the Chinese mainland. Within this area, estimates of birth rates and death rates have been made at various times in different localities from the results of local investigations. Many such estimates have been quoted by Chen in a book published in 1944 [14], with birth rates ranging from 12.2 to 58.4, and death rates from 13.0 to 37.1, per 1,000. Perhaps because investigating techniques improved, the rates recorded in the early surveys were generally lower than in the later. Among some of the more noteworthy results one may quote the birth rates of 42.2 and 38.3, and the death rates of 27.9 and 27.1, observed by J. L. Buck [15], as well as a life-table, based on experimental registration in 1939–43 in the area of Cheng Kung (Yunnan Province) where an expectation of life at birth (both sexes) of 32.8 years has been calculated.[16] But, as in the case of vital registration, there is also a tendency in enumerative surveys to omit an unknown number of births and deaths, particularly the latter.[17]

More recently, new efforts have been made to determine birth and death rates on the Chinese mainland through local surveys.[18] Studies conducted in 1952–54 in 16 different areas have yielded birth rates ranging from 26.1 to 52.8, and death rates from 13.4 to 24.0, per 1,000; the weighted averages are 41.6 for the birth rate and 21.0 for the death rate, subject to interpretation of the accuracy of the surveys, on which information is not at hand. Assuming continued improvement in survey techniques, a comparison of recent with earlier results suggests that typical average birth rates on the Chinese mainland are well over 40 per 1,000, whereas average death rates, previously amounting to possibly 30 per 1,000 if not more, have probably declined recently to an extent which cannot be accurately determined. To verify the level of death rates is very difficult : earlier population estimates have depended on partial enumerations which were less complete than the census conducted in 1953, and a rate of population growth cannot be reliably calculated from figures clearly lacking in consistency. Some confirmation of the level of the birth rate may be sought from population age structure, as reported in 1953 [19], though it must be pointed out that during the years of war and revolution birth rates on the Chinese mainland probably were lower than they would have been had more normal conditions prevailed. A com-

[8] Kingsley Davis, *The Population of India and Pakistan* (Princeton, 1951), page 85.

[9] This study, which has been carried out at the Princeton Office of Population Research, will be published by the Princeton University Press in 1958.

[10] *Report on the World Social Situation*, op. cit.

[11] *Ibid.* The assessed crude death rates for 1950–55 are : 28 for India, and 30 for Pakistan.

[12] W. F. Wertheim, " La Population de l'Indonésie et le Test des 40 % ", *Population* (Paris), October-December 1954, pp. 655-674.

[13] *Report on the World Social Situation*, op. cit.

[14] Ta Chen, *Population in Modern China*, Chicago, 1944.

[15] J. L. Buck, *Land Utilization in China*, Shanghai, 1937.

[16] Ta Chen, op. cit.

[17] One method is to enquire about births and deaths which have occurred during a specified past period in households visited by investigators. Where a child was born, whether still living or not, its parent will probably be present to report this fact, but it is less certain that a respondent will be found to report on the death of a person who may no longer be considered a former member of the household and may have died in a different locality.

[18] Ta Chen, " New China's Population Census of 1953 and its Relations to National Reconstruction and Demographic Research ", paper submitted to the 30th session of the International Statistical Institute, Stockholm, 8–15 August 1957.

[19] Data provided by Ta Chen in the paper cited above.

parison of age structures as implied in our model and as reported for the date the 1953 census is presented below.

Age group	Per cent of total population, according to Population model [a]	Per cent of total population, according to 1953 census on Chinese mainland [b]
0–4	16.1	15.6
5–14	24.6	20.3
15–24	19.5	17.3
25–34	14.8	14.6
35–44	10.8	12.0
45–54	7.3	9.3
55–64	4.3	6.5
65–74	2.0	3.4
75 and over	0.5	1.0

[a] Assuming constant expectation of life of 30 years and a constant gross reproduction rate of 3.

[b] Source: Ta Chen's paper before the 30th session of the International Statistical Institute.

Comparison of the two sets of figures at first sight reveals that the census shows lower percentages at ages under 25 and higher percentages at ages over 34, suggesting that fertility has been over-estimated in the model. On the other hand, long periods of internal disorders and warfare may have introduced distortions in the age structure when, under more peaceful conditions, fertility would ordinarily be high. This seems to suggest itself if a comparison is made between the estimated and the recorded ratios of persons aged 0–4, and 25–34, respectively. According to the model estimates, the ratio is one of 16.1 to 14.8, or 109 to 100; according to the census data, it is 15.6 to 14.6, i.e., 107 to 100, which is almost as much, in view of the fact that in most censuses some of the small children fail to be enumerated. That fertility under normal conditions may be high on the Chinese mainland also seems likely from the fact that birth rates approaching 50 per 1,000 have been recorded for the predominantly Chinese populations of Taiwan and Singapore.[20]

The discussion concerning population trends on the Chinese mainland has been presented at some length because of its considerable impact on rates of world population growth. Information regarding this population has recently been improved but much fuller detail is needed before an adequate assessment can be made. It is evident that the simple model used in the projection misrepresents considerably the current age structure, as reported for 1953 census. Internal disorders over a long period of the past make it difficult to evaluate whether the normal level of fertility is really as high as in the model though, perhaps, it is not very much lower. To judge from the evidence of the Cheng Kung life table, mortality in at least one part of China may have been as high some ten years ago, as in the model, but it is possible that current mortality in China is considerably lower. The model, therefore, does not necessarily exaggerate the rate of current population growth in China.

A different model was selected to represent approximate conditions in the area of *Japan and the Ryukyu Islands*. In the model, an expectation of life of 68.2 years is attained in 1950, while the gross reproduction rate, equal to 2.25 in 1925, is assumed to have declined to 1.5 by 1950 and to 1.25 by 1955. According to the model, the birth rate should be 22.2 on the average of 1950–55, and 18.5 on the average of 1955–60, while the death rate should be 6.6, and 6.3, in the two periods.

Because of the effects of the Second World War, population trends in Japan have been far less regular in the past than those assumed in the simplified model. Nevertheless, the average recorded birth rate in 1950–55 amounted to 22.9 per 1,000, while a rate of 18.4 was observed in 1956. Mortality has been under-estimated in the model, even though the Japanese death rate has rapidly and continuously declined to an average of 9.1 during 1950–55 and 8.0 in 1956.

5. Europe

One model has been used as an approximation to the population trends in both *Northern and Western Europe*, and *Central Europe*. In both, it is assumed that expectation of life has attained 68.2 years by 1950, and that fertility, after an early decline, reached minimum levels in the 1930s from which it has recovered subsequently to attain an average gross reproduction rate of 1.25.

Because of the varying effects of the economic depression in the 1930s and the events of the Second World War, population trends have been more complicated. A comparison is made below between the models and the rates actually observed in the most populous countries of the two European regions in the matter of crude birth rates and crude death rates.

[20] For Hong Kong, an average birth rate of 33.8 per 1,000 was recorded during 1950–55, but this rate is unrepresentative since a large part of Hong Kong's population consists of recent immigrants. Birth rates of this level were also reported for Singapore in earlier periods.

Period	Assumed birth rates	Birth rates recorded in: United Kingdom	France	Netherlands	Germany: Western	Germany: Eastern	Poland
1925–30	22.5	17.6	18.5	23.4	—	19.7 —	33.0
1930–35	18.6	15.8	17.2	21.7	—	16.3 —	28.9
1935–40	17.7	15.3	15.1	20.3	—	19.4 —	25.4
1940–45	19.5	16.0	15.5	22.0	—	17.2 [a] —	...
1945–50	19.8	18.3	20.5	25.9	16.5 [b]	13.4 [b]	28.9 [c]
1950–55	18.5	15.8	19.3	22.0	15.8	16.5	30.0

[a] 1940–43.

[b] 1946–50.

[c] 1947–50.

Period	Assumed death rates	Death rates recorded in : United Kingdom	France	Netherlands	Germany Western	Germany Eastern	Poland
1925–30	11.9	12.5	17.3	10.0	—	11.9 —	17.0
1930–35	10.9	12.2	15.9	9.9	—	11.0 —	15.0
1935–40	10.3	12.2	15.6	8.7	—	11.9 —	14.0
1940–45	10.0	13.1	17.6	10.8	—	12.2 [a] —	...
1945–50	9.8	12.2	13.4	8.7	11.1 [b]	16.8 [b]	11.5 [c]
1950–55	9.5	12.0	13.2	7.5	10.6	11.9	10.9

[a] 1940–43.
[b] 1946–50.
[c] 1947–50.

As a result of different past trends, current age structures also vary amongst themselves. The recorded data on age structure are compared with the model below.

Age group	Per cent of total population contained in each age group according to Model	England & Wales 1951	France 1954	Netherlands 1947	Germany 1946	Austria 1951	Czechoslovakia 1947
0–14	24.7	22.1	23.3	29.3	24.4	22.9	24.3
15–29	22.7	20.4	21.2	24.4	19.6	20.8	24.0
30–44	22.4	22.3	18.7	20.6	22.4	19.8	22.9
45–59	17.4	19.2	19.8	15.0	19.5	20.8	17.3
60–74	10.2	12.3	12.6	8.7	11.6	12.4	9.2
75 and over	2.7	3.6	4.4	2.1	2.4	3.2	2.3
TOTAL ...	100.0	100.0	100.0	100.0	100.0	100.0	100.0

As can be seen, there is a considerable variation in past trends and structure among the several national populations. From statistical compilations, the following averages have been inferred.[21] For *Northern and Western Europe*, the birth rate in 1951–55 averaged 18, and the death rate 11; around 1950, 24 per cent of the population were aged under 15, 61 per cent were aged 15–59, and 15 per cent were aged 60 and over. For *Central Europe*, the average birth rate was 20, the average death rate 11, and the percentages in the three respective age groups 24, 62 and 14. In the models, as applied to both regions, there is an average birth rate (1950–55) of 18.5 and an average death rate of 9.5, while 24.7 per cent are aged under 15, 62.4 per cent 15–59, and 12.9 per cent are aged 60 and over. The models, therefore, under-estimate somewhat the extent of aging and mortality in both areas, as well as average fertility in Central Europe.

With regard to *Southern Europe*, conditions were assumed to approximate the average of two models, one of which has been used in relation to Northern, Western, and Central Europe, and the other in the case of Japan. The implication is that, whereas by 1950 expectation of life attains 68.2 years, and by 1955 the gross reproduction rate settles at 1.25, past trends in fertility have shown a more recent decline than in other parts of Europe, though not as rapid as in the case of Japan. Crude vital rates as assumed and as actually observed in the most populous countries of Southern Europe are shown below.

The weighted average of birth rates, 1951–55, as resulting from statistical compilations [22], is 21, while the average death rate is 10. Mortality, evidently, is under-estimated in the model, though less for the current than for earlier periods.

[21] *Demographic Yearbook 1956* (United Nations publication, Sales No. : 1956.XIII.5).

[22] *Demographic Yearbook 1956*, op. cit.

Period	Assumed birth rates	Birth rates recorded in Spain	Italy	Yugoslavia	Romania
1925–30	28.2	28.7	27.2	33.9	35.4
1930–35	25.2	27.5	24.5	33.0	33.7
1935–40	23.6	22.0	23.2	27.9	30.2
1940–45	23.4	21.9	20.1	...	25.0
1945–50	22.5	22.0	22.7	28.8 [a]	...
1950–55	20.4	20.4	18.2	28.5	24.7 [b]

[a] 1947–50.
[b] 1951–56.

Period	Assumed death rates	Death rates recorded in Spain	Italy	Yugoslavia	Romania
1925–30	11.8	18.4	16.6	20.0	21.6
1930–35	10.6	16.5	14.1	18.4	20.3
1935–40	9.6	17.9	13.9	15.9	20.0
1940–45	9.0	14.9	14.5	...	19.2
1945–50	8.4	10.3	11.3	13.2 [a]	...
1950–55	8.0	10.1	9.8	12.3	9.9 [b]

[a] 1947–50.

[b] 1951–56.

As regards age structure, the following comparison can be made:

Age group	Per cent of total population contained in each age group, according to Model	Portugal 1950	Italy 1951	Yugoslavia 1953	Romania 1948
0–14	28.9	29.5	26.3	30.6	28.9
15–29	24.9	26.7	25.3	29.0	47.0 [a]
30–44	21.0	19.3	20.3	17.1	
45–59	15.0	14.0	15.9	14.4	15.9 [b]
60–74	8.2	8.2	9.6	7.2	8.2 [c]
75 and over	2.1	2.3	2.6	1.7	
TOTAL ...	100.0	100.0	100.0	100.0	100.0

[a] 15-44.

[b] 45-60.

[c] 61 and over.

Compilation of all available census statistics [23] results in these estimates for 1950: 28 per cent under 15, 61 per cent 15–59, and 9 per cent 60 and over. According to the models, the three percentages would be 28.9, 60.8, and 10.3, respectively. The agreement seems quite satisfactory.

6. OCEANIA

For *Australia and New Zealand*, the same model has been taken as for Northern America. According to this, expectation of life would have attained 68.2 years in 1950, the gross reproduction rate being 1.5; fertility would have declined at an early date, passing through a minimum in the 1930s and making a subsequent substantial recovery. The comparison of birth and death rates, according to the model and as actually observed, gives these results.

[23] *Ibid.* The figures total less than 100 per cent.

Period	Crude birth rate: Assumed in model	Observed in Australia	Observed in New Zealand	Crude death rate: Assumed in model	Observed in Australia	Observed in New Zealand
1925–30	22.5	21.6	20.2	11.9	9.4	8.6
1930–35	18.6	17.6	17.5	10.9	8.8	8.3
1935–40	18.7	17.2	17.4	10.4	9.6	9.0
1940–45	22.3	19.9	21.6	10.1	10.9	10.1
1945–50	23.0	23.2	25.3	9.6	9.8	9.4
1950–55	21.3	22.9	24.6	9.2	9.3	9.2

The agreement is fairly good except that current fertility is somewhat under-estimated, while mortality for earlier periods has been over-estimated. With respect to age structure, the following comparison is obtained.

Age group	Per cent of population in each age group: Model (1950)	Australia (1947 census)	New Zealand (1951 census)
0–14	27.3	25.2	29.4
15–29	21.9	23.7	21.6
30–44	21.6	21.8	20.8
45–59	16.8	17.0	15.0
60 and over	12.4	12.3	13.2

The agreement is remarkably good in view of the fact that, at various periods in the past, immigration has contributed substantially to population growth. The effects of migration on age structure, evidently, have not been very great.

No model was assumed to approximate conditions in the region of the *Pacific Islands*. Little is known about population trends in Papua and New Guinea, under Australian administration, though probably fertility and mortality are both very high. In Hawaii, demographic conditions resemble more nearly those of Western countries. Other populations are small, and conditions are diverse. No

model could be devised to represent average conditions throughout this wide area.

7. The Soviet Union

The model taken to represent demographic trends in the *Soviet Union* may stray considerably from the facts but in view of the limited information only simple assumptions could be made.

Mortality is undoubtedly under-estimated since, according to the model, an expectation of life of 68.2 years would have been reached in 1950, while an expectation of 64 years was reported in 1956.[24] In the model population, the crude death rate would have been about 8.5 per 1,000 in 1940, and 6.6 per 1,000 in 1950–55, while the reported death rates are 18.3 for 1940, and an average of 9.3 for 1950–55 (8.4 in 1955). In view of the rapid progress registered in the statistics, it is not unlikely that in the near future the mortality conditions assumed in the model will actually be attained.

With regard to fertility, the assumption in the model is one of recent decline to a current gross reproduction rate of 1.5. Because of rapid social changes in the period of the early economic plans and the severe disruption of living conditions during the Second World War, actual fertility trends could not have been nearly as regular as assumed in the model. The model population would have had a birth rate of about 28.5 in 1940, and 24.1 in 1950–55, while recorded rates are 31.7 for 1940 and 26.1 on the average of 1950–55 (25.6 in 1955). The secular trend quite possibly may have been similar to that of the model, but wide fluctuations around this trend must have occurred.[25]

There are no recent statistics on the age structure of the Soviet population, but various events, and especially the heavy losses suffered in both world wars, must have introduced considerable irregularities into the shape of the age pyramid, which the simple model cannot reflect. Rather surprisingly, and partly through compensatory effects, the irregularities tend to disappear when the figures are combined in 15–year age groups. This appears from the comparisons made below, which are for : (*a*) the model as calculated for 1925 and the results of the 1926 census; (*b*) the model as calculated for 1940 and adjusted results of the 1939 census, brought forward to 1940;[26] and (*c*) the model as calculated for 1950 and a detailed projection of the Soviet population for the same date carried out several years ago.[27] Though the two independent estimates for the year 1950 seem to agree very well, whether they approximate the actual facts of the situation remains in grave doubt so long as either adequate statistics of current age structure, or adequate information on population losses and the birth deficit during the Second World War are not available.[28]

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[24] M. D. Kovrygina in *Pravda*, 29 November 1956.

[25] Vital statistics for a period around the date of the 1926 census are available, but recording at that time was somewhat incomplete. For the European part of the Soviet Union, a birth rate of 43.5 and a death rate of 19.9 per 1,000 were recorded in 1926. The birth rate probably was unusually high in that year, being a temporary revival following upon a long period disturbed by the First World War and civil wars. In view of the probably incomplete recording of deaths, Lorimer has estimated a death rate of 26.0 for that year (Frank Lorimer, *The Population of the Soviet Union : History and Prospects*, League of Nations, Geneva, 1946). These rates are in great contrast with a birth rate of 34.9 and a death rate of 12.3 which would have occurred in 1925 in the model population.

[26] Results of the 1939 census have not been published by conventional 5–year age groups, but suitable interpolations have been made by F. Lorimer, op. cit. The statistics refer to pre-1939 boundaries.

[27] The projection is that of F. Lorimer, op. cit. The following assumptions were made : an increase in the expectation of life from 46.7 years in 1940 to 52.7 by 1955 and 58.2 by 1970; a decline in the gross reproduction rate from 2.06 in 1940 to 1.16 by 1970; and a population deficit caused by the Second World War hypothetically taken as 20 million, composed of 5 million military casualties, 9 million civilian casualties, and a war-time birth deficit of 6 million. Current mortality has been over-estimated and current fertility has been estimated approximately correctly. As regards the war-time population deficit, data to confirm the hypothetical assumptions are entirely lacking.

[28] A population census of the Soviet Union, to be taken in 1959, is now being planned.

	Per cent of total population in each age group					
	1925		*1940*		*1950*	
Age group	*Model*	*Census (1926)*	*Model*	*Census (1939)* [a]	*Model*	*Projection*[b]
0–14	39.4	37.2	36.1	36.0	33.1	32.5
15–29	27.6	29.1	27.3	27.5	27.1	27.2
30–44	17.3	16.7	18.8	19.8	19.6	20.6
45–59	10.0	10.3	11.3	10.3	12.6	12.7
60–74	4.8	5.5	5.3	5.4	6.1	5.8
75 and over	1.0	1.2	1.2	1.1	1.5	1.2

[a] Tabulated results of 1939 census interpolated by 5-year age groups and brought forward to 1940 (Lorimer, *The Population of the Soviet Union...*).

[b] Assumptions : mortality decline less rapid than observed; fertility decline to approximate level observed in 1950; hypothetical war losses, as yet unverified.

8. Summary

The models have been compared with available statistics on regional populations in respect of birth rates, death rates and age structure. Most of the approximations have been found fairly good so far as could be determined, though certain defects in the models had to be recognized. The defects are not so severe as to invalidate the models for purposes of population projections, if adjustments are made to bring them more closely into line with specific statistical observations. The defects which could be determined are summarized below.

Region	Apparent defects of models, as verified by available statistics		
	Birth rate	Death rate	Age structure
Northern Africa	—	—	—
Middle Africa	perhaps too low	perhaps too low	perhaps too few children
Southern Africa	perhaps too high	perhaps too high	too many children
Northern America	somewhat too low	—	slightly too many aged persons
Central America	—	perhaps too high	—
Caribbean	—	—	—
Tropical South America	perhaps too low	—	—
Temperate South America	too low	too low	—
South-West Asia	—	perhaps too high	perhaps too many children
Central South Asia	—	—	—
South-East Asia	—	probably somewhat too high	—
East Asia (without Japan)	perhaps too high	probably too high	too many children; too few aged persons
Japan	(actual trend still difficult to assess)	too low	—
Northern and Western Europe	—	too low	too few aged persons
Central Europe	somewhat too low	too low	too few aged persons
Southern Europe	—	too low	—
Australia and New Zealand	somewhat too low	—	—
Pacific Islands	—	—	—
Soviet Union	somewhat too low	too low	—

Appendix B

DETAILED TABLES OF MODEL POPULATIONS

EXPLANATORY NOTE

1. To facilitate practical application in population projections, the tables have been arranged so that, in regard to an actual population of a given type, the first 25-year period corresponds to the past (1925-1950), and the subsequent 25-year periods to the future (1950–1975 and 1975–2000). Since 1950 has been taken as the base year of the projections, the models have been pro-rated so as to total 10,000 at the end of the first 25-year period, and the pertinent figures have been italicized.

2. Models BC and EI, which have actually been applied to future periods, had to be inserted in the lower left-hand corner of tables I and II. With these exceptions, the models have been arranged in continuous sequences of 75 years. Two models have been placed underneath each other to facilitate significant comparisons of the effects of variation (past or future) in the fertility trend on resulting population changes.

3. The tables are furthermore intended to provide the detailed material for the theoretical study outlined in chapter IV. In that chapter, analysis was confined to broad age groups only (0–14, 15–59 and 60 years and over) but the user may, if he so wishes, extend the comparisons made there to the more detailed age groups.

4. Models NT, SO and SX have not been included because of their limited theoretical interest.

TABLE I. GROWTH OF POPULATION, BY FIVE-YEAR AGE GROUPS, DURING FIVE-YEAR INTERVALS OF TIME, ACCORDING TO MODELS AB, BC, CD, DE, CG AND GJ

Age (in years)	A (B) 0 (25)	AB (or BC), 0-25 (or 25-50) 5 (30)	10 (35)	15 (40)	20 (45)	B (C) 25 (50)	Time (in years) 55	60	65	70	D 75	80	85	90	95	E 100
0–4	1 182	1 258	1 339	1 425	1 517	*1 615*	1 750	1 932	2 139	2 383	2 678	3 042	3 487	4 026	4 678	5 469
5–9	949	1 010	1 075	1 144	1 218	*1 297*	1 397	1 540	1 725	1 935	2 180	2 476	2 839	3 283	3 821	4 473
10–14	849	904	962	1 023	1 089	*1 159*	1 241	1 344	1 488	1 675	1 884	2 129	2 425	2 788	3 281	3 769
15–19	759	808	860	916	975	*1 038*	1 111	1 194	1 299	1 448	1 627	1 838	2 083	2 379	2 742	3 184
20–24	669	712	758	807	859	*915*	980	1 054	1 139	1 244	1 388	1 572	1 782	2 026	2 321	2 684
25–29	582	620	660	703	749	*797*	854	919	995	1 081	1 186	1 331	1 514	1 724	1 968	2 263
30–34	502	534	569	606	645	*687*	737	795	863	939	1 027	1 134	1 279	1 461	1 671	1 915
35–39	428	456	486	517	550	*585*	629	681	741	810	889	978	1 086	1 231	1 413	1 624
40–44	360	383	408	434	462	*492*	529	574	628	690	761	841	931	1 040	1 185	1 366
45–49	297	316	336	358	381	*406*	436	475	522	577	640	712	792	883	992	1 136
50–54	238	253	269	286	305	*325*	350	383	423	470	525	588	659	739	830	938
55–59	184	196	209	222	236	*251*	271	297	330	369	416	469	531	601	679	768
60–64	134	143	152	162	173	*184*	198	218	243	275	312	356	407	466	532	607
65–69	90	96	102	109	116	*124*	134	147	165	188	216	250	290	336	389	449
70–74	54	57	61	65	69	*73*	79	88	99	114	133	156	184	216	255	300
75–79	26	28	30	32	34	*36*	38	43	49	58	68	81	98	118	142	171
80–84	8	9	10	11	12	*13*	14	16	18	22	27	33	41	50	62	77
85	2	2	2	3	3	*3*	3	4	5	6	7	10	12	16	21	27
All ages	7 313	7 785	8 288	8 823	9 393	*10 000*	10 751	11 704	12 871	14 277	15 965	17 996	20 440	23 383	26 932	31 220

Age (in years)	B 25	30	35	40	45	C 50	C 50	Time (in years) 55	60	65	70	G 75	80	85	90	95	J 100
0–4	*1 615*	1 719	1 830	1 948	2 074	2 208	*1 615*	1 707	1 787	1 873	1 964	2 054	2 136	2 202	2 247	2 267	2 257
5–9	*1 297*	1 381	1 470	1 565	1 666	1 774	*1 297*	1 397	1 502	1 596	1 695	1 797	1 899	1 994	2 073	2 182	2 168
10–14	*1 159*	1 234	1 314	1 399	1 489	1 585	*1 159*	1 241	1 344	1 451	1 548	1 650	1 755	1 860	1 958	2 040	2 103
15–19	*1 038*	1 105	1 176	1 252	1 333	1 419	*1 038*	1 111	1 194	1 299	1 407	1 506	1 610	1 717	1 825	1 925	2 011
20–24	*915*	974	1 037	1 104	1 175	1 251	*915*	980	1 054	1 139	1 244	1 354	1 454	1 561	1 670	1 781	1 885
25–29	*797*	848	903	961	1 023	1 089	*797*	854	920	995	1 081	1 186	1 298	1 401	1 509	1 622	1 736
30–34	*687*	731	778	828	881	938	*687*	736	795	863	939	1 027	1 134	1 247	1 352	1 463	1 578
35–39	*585*	623	663	706	752	800	*585*	629	681	741	810	889	978	1 086	1 200	1 308	1 421
40–44	*492*	524	558	594	632	673	*492*	529	574	628	690	761	841	931	1 040	1 155	1 264
45–49	*406*	432	460	490	522	556	*406*	436	475	522	577	640	712	792	883	992	1 108
50–54	*325*	346	368	392	417	444	*325*	350	383	423	470	525	588	659	739	830	938
55–59	*251*	267	284	302	322	343	*251*	271	297	330	369	416	470	531	601	679	767
60–64	*184*	196	209	222	236	251	*184*	198	218	243	275	312	356	407	466	532	607
65–69	*124*	132	140	149	159	169	*124*	134	147	165	188	216	250	290	336	389	449
70–74	*73*	78	83	88	94	100	*73*	79	88	99	114	133	156	184	216	255	300
75–79	*36*	38	40	43	46	49	*36*	38	43	49	58	68	81	98	118	142	171
80–84	*13*	14	15	16	17	18	*13*	14	18	19	22	27	33	40	50	62	77
85	*3*	3	3	4	4	4	*3*	3	4	5	6	7	10	12	16	21	27
All ages	*10 000*	10 645	11 331	12 063	12 842	13 671	*10 000*	10 707	11 522	12 440	13 457	14 568	15 761	17 012	18 299	19 595	20 867

TABLE II. GROWTH OF POPULATION BY FIVE-YEAR AGE GROUPS, DURING FIVE-YEAR INTERVALS OF TIME, ACCORDING TO MODELS CD, DE, EF, EI, DH AND HL.

Age (in years)	C 50	55	60	65	70	D 75	80	85	90	95	E 100	105	110	115	120	F 125
							Time (in years)									
0–4	1 011	1 096	1 209	1 340	1 493	*1 677*	1 905	2 184	2 522	2 930	3 425	4 033	4 790	5 727	6 879	8 287
5–9	812	875	965	1 080	1 212	*1 365*	1 551	1 779	2 056	2 394	2 802	3 298	3 908	4 670	5 615	6 780
10–14	726	777	841	932	1 048	*1 180*	1 333	1 519	1 746	2 024	2 361	2 769	3 265	3 876	4 639	5 586
15–19	650	696	748	813	904	*1 019*	1 152	1 305	1 490	1 717	1 994	2 332	2 740	3 236	3 848	4 612
20–24	573	614	660	713	779	*870*	984	1 116	1 269	1 454	1 681	1 958	2 295	2 704	3 202	3 815
25–29	499	535	576	623	677	*743*	834	948	1 079	1 232	1 417	1 644	1 921	2 259	2 669	3 169
30–34	430	461	498	540	588	*643*	710	801	915	1 047	1 200	1 385	1 612	1 890	2 228	2 639
35–39	367	394	426	464	508	*557*	613	680	771	885	1 016	1 170	1 355	1 582	1 861	2 199
40–44	309	331	360	393	432	*477*	527	583	651	742	856	987	1 140	1 325	1 552	1 830
45–49	254	273	298	328	362	*401*	446	496	553	621	712	824	955	1 107	1 291	1 517
50–54	205	219	240	265	294	*329*	368	413	463	520	587	676	787	916	1 066	1 248
55–59	157	170	186	206	231	*260*	294	333	376	425	481	547	634	742	867	1 013
60–64	115	124	136	152	172	*195*	223	255	292	333	380	433	496	579	682	802
65–69	77	84	92	105	118	*136*	157	182	211	244	282	324	374	432	508	603
70–74	46	50	55	62	72	*83*	98	115	136	160	188	220	257	300	350	416
75–79	22	24	27	31	36	*43*	51	61	74	89	107	128	153	182	215	255
80–84	8	9	10	12	14	*17*	20	25	32	39	48	60	73	89	108	130
85	2	2	2	3	4	*5*	6	8	10	13	17	22	28	35	44	55
All ages	6 263	6 734	7 331	8 062	8 942	*10 000*	11 272	12 803	14 646	16 869	19 554	22 810	26 783	31 651	37 624	44 956

Age (in years)	E 100	105	110	115	120	I 125	D 75	80	85	90	95	H 100	105	110	115	120	L 125
								Time (in years)									
0–4	*1 752*	2 011	2 266	2 564	2 899	3 248	*1 677*	1 858	2 021	2 208	2 415	2 627	2 830	3 020	3 189	3 325	3 410
5–9	*1 433*	1 686	1 949	2 210	2 514	2 856	*1 365*	1 551	1 735	1 903	2 096	2 309	2 529	2 742	2 944	3 127	3 277
10–14	*1 207*	1 416	1 670	1 933	2 195	2 501	*1 180*	1 333	1 519	1 704	1 873	2 068	2 282	2 504	2 720	2 925	3 111
15–19	*1 020*	1 192	1 401	1 655	1 919	2 183	*1 019*	1 152	1 305	1 490	1 674	1 846	2 041	2 258	2 482	2 700	2 908
20–24	*859*	1 001	1 174	1 383	1 637	1 903	*870*	984	1 116	1 269	1 454	1 639	1 813	2 010	2 228	2 455	2 677
25–29	*725*	841	983	1 156	1 365	1 621	*743*	834	948	1 079	1 232	1 417	1 603	1 778	1 978	2 200	2 430
30–34	*613*	708	824	966	1 140	1 350	*643*	710	801	915	1 047	1 200	1 385	1 571	1 749	1 952	2 175
35–39	*520*	598	693	809	951	1 125	*557*	613	680	771	885	1 016	1 170	1 355	1 543	1 721	1 926
40–44	*438*	505	583	678	794	936	*477*	527	583	651	742	856	987	1 140	1 325	1 513	1 693
45–49	*364*	422	488	566	660	776	*401*	446	496	553	621	712	824	955	1 107	1 291	1 479
50–54	*300*	346	403	468	545	638	*329*	368	413	463	520	587	676	787	916	1 066	1 248
55–59	*246*	280	324	379	443	518	*260*	294	333	376	425	481	547	634	742	867	1 013
60–64	*194*	222	254	296	349	410	*195*	223	255	292	333	380	433	496	579	682	802
65–69	*144*	166	191	221	260	308	*136*	157	182	211	244	282	324	374	432	508	603
70–74	*96*	113	132	153	179	213	*83*	98	115	136	160	188	220	257	300	350	416
75–79	*55*	66	78	93	110	130	*43*	51	61	74	89	107	128	153	182	215	254
80–84	*25*	30	37	46	55	66	*17*	20	25	32	39	48	60	73	89	108	130
85	*9*	11	14	18	23	28	*5*	6	8	10	13	17	22	28	35	44	55
All ages	*10 000*	11 614	13 464	15 594	18 038	20 810	*10 000*	11 225	12 596	14 135	15 862	17 778	19 874	22 135	24 540	27 049	29 607

TABLE III. GROWTH OF POPULATION BY FIVE-YEAR AGE GROUPS, DURING FIVE-YEAR INTERVALS OF TIME, ACCORDING TO MODELS HL, LMN, NO, JUKL, LMN AND NO

Age (in years)	H					L	M				N					O
	Time (in years)															
	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0–4	888	956	1 020	1 077	1 123	*1 152*	1 218	1 333	1 440	1 534	1 624	1 727	1 851	1 987	2 130	2 275
5–9	780	854	926	994	1 056	*1 107*	1 140	1 209	1 327	1 435	1 530	1 620	1 722	1 846	1 981	2 122
10–14	698	771	846	919	988	*1 051*	1 103	1 137	1 207	1 325	1 433	1 528	1 618	1 720	1 843	1 979
15–19	623	689	763	838	912	*982*	1 046	1 099	1 134	1 205	1 322	1 430	1 525	1 615	1 718	1 840
20–24	554	612	679	753	829	*904*	976	1 041	1 095	1 131	1 202	1 319	1 427	1 522	1 611	1 713
25–29	479	541	600	668	743	*821*	897	970	1 036	1 091	1 127	1 198	1 316	1 423	1 517	1 607
30–34	405	468	531	591	660	*735*	813	891	965	1 032	1 087	1 123	1 193	1 310	1 417	1 511
35–39	343	395	457	521	581	*650*	727	806	884	959	1 026	1 081	1 117	1 187	1 303	1 409
40–44	290	333	385	448	511	*572*	647	718	798	876	951	1 017	1 071	1 107	1 177	1 292
45–49	240	278	322	374	436	*499*	560	630	707	787	865	938	1 004	1 057	1 092	1 161
50–54	198	228	266	309	360	*421*	484	545	614	691	769	846	917	981	1 034	1 068
55–59	163	185	214	250	293	*342*	402	464	523	592	666	742	815	885	946	997
60–64	128	146	168	196	230	*271*	318	375	435	492	558	628	700	769	834	892
65–69	95	110	126	146	172	*203*	241	285	338	393	447	506	569	634	697	756
70–74	63	74	87	101	118	*141*	168	201	239	286	334	380	430	484	539	593
75–79	36	43	52	61	73	*86*	103	125	151	182	219	256	291	329	370	413
80–84	16	20	25	30	36	*44*	53	65	79	97	118	142	166	189	214	240
85	6	7	9	12	15	*19*	23	28	35	44	55	67	81	95	110	125
All ages	6 005	6 712	7 476	8 288	9 136	*10 000*	10 914	11 922	13 007	14 152	15 333	16 548	17 813	19 140	20 533	21 993

Age (in years)	J		U		K	L	M				N					O
	Time (in years)															
	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0–4	834	789	697	743	952	*1 064*	1 061	1 062	1 118	1 232	1 354	1 452	1 534	1 621	1 729	1 860
5–9	800	802	765	679	728	*938*	1 053	1 054	1 057	1 114	1 229	1 350	1 448	1 529	1 616	1 724
10–14	776	791	795	759	675	*724*	935	1 050	1 052	1 055	1 113	1 227	1 348	1 447	1 527	1 614
15–19	742	768	783	788	753	*671*	721	931	1 048	1 050	1 053	1 111	1 225	1 346	1 444	1 524
20–24	696	729	755	772	779	*747*	666	717	928	1 045	1 048	1 051	1 109	1 222	1 343	1 440
25–29	641	681	715	743	763	*771*	741	662	715	925	1 041	1 044	1 048	1 106	1 219	1 339
30–34	583	626	667	703	732	*754*	764	736	659	711	921	1 038	1 040	1 043	1 101	1 214
35–39	525	568	613	655	693	*724*	746	758	730	655	708	916	1 032	1 034	1 038	1 095
40–44	467	509	554	599	643	*681*	714	737	750	724	650	701	908	1 023	1 026	1 029
45–49	409	450	493	538	584	*628*	668	701	726	739	714	641	692	896	1 009	1 012
50–54	346	389	429	473	518	*564*	609	649	683	709	723	698	627	677	876	987
55–59	283	322	364	404	447	*492*	538	583	623	658	684	697	673	604	652	845
60–64	224	255	293	333	372	*414*	458	503	546	587	620	644	657	635	570	615
65–69	166	191	220	255	292	*329*	368	410	453	495	532	563	584	596	576	517
70–74	111	130	152	177	206	*239*	272	307	344	383	420	452	478	497	507	489
75–79	63	76	90	107	127	*150*	176	202	231	262	293	322	346	366	380	388
80–84	29	35	43	52	64	*77*	92	110	128	149	170	190	209	224	237	247
85	10	13	16	21	26	*33*	40	50	60	72	85	99	112	124	135	144
All ages	7 705	8 124	8 444	8 801	9 354	*10 000*	10 622	11 222	11 851	12 565	13 358	14 196	15 070	15 990	16 985	18 083

TABLE IV. GROWTH OF POPULATION BY FIVE-YEAR AGE GROUPS, DURING FIVE-YEAR INTERVALS OF TIME, ACCORDING TO MODELS HL, LRS, ST, JUPQ, ARS AND ST

Age (in years)	Time (in years) H 100	105	110	115	120	L 125	R 130	135	140	145	S 150	155	160	165	170	T 175
0–4	888	956	1 020	1 077	1 123	*1 152*	1 117	1 113	1 202	1 276	1 324	1 349	1 378	1 427	1 489	1 549
5–9	780	854	926	994	1 056	*1 107*	1 140	1 109	1 108	1 198	1 272	1 320	1 345	1 374	1 423	1 484
10–14	698	771	846	919	988	*1 051*	1 103	1 137	1 107	1 106	1 196	1 271	1 319	1 343	1 372	1 421
15–19	623	689	763	838	912	*982*	1 046	1 099	1 134	1 105	1 104	1 194	1 269	1 316	1 341	1 370
20–24	554	612	679	753	829	*904*	976	1 041	1 095	1 131	1 103	1 102	1 192	1 266	1 313	1 338
25–29	479	541	600	668	743	*821*	897	970	1 036	1 091	1 128	1 099	1 099	1 188	1 262	1 309
30–34	405	468	531	591	660	*735*	813	891	965	1 032	1 087	1 123	1 095	1 094	1 183	1 257
35–39	343	395	457	521	581	*650*	727	806	885	959	1 026	1 081	1 117	1 089	1 088	1 178
40–44	290	333	385	448	511	*572*	642	718	798	877	951	1 017	1 071	1 107	1 080	1 079
45–49	240	278	322	374	436	*499*	560	630	707	787	865	938	1 003	1 057	1 092	1 065
50–54	198	228	266	309	360	*421*	484	545	614	691	769	846	917	981	1 034	1 068
55–59	163	185	214	250	293	*342*	402	464	523	592	666	742	815	885	946	997
60–64	128	146	168	196	230	*271*	318	375	435	492	558	628	700	769	834	892
65–69	95	110	126	146	172	*203*	241	285	338	393	447	506	569	635	697	756
70–74	63	74	87	101	118	*141*	168	201	240	286	334	380	430	484	539	593
75–79	36	43	52	61	73	*86*	103	125	151	182	219	256	291	330	371	413
80–84	16	20	25	30	36	*44*	53	65	79	97	118	142	166	189	214	240
85	6	7	9	12	15	*19*	23	28	35	44	55	67	81	95	110	125
All ages	6 005	6 712	7 476	8 288	9 136	*10 000*	10 813	11 602	12 452	13 339	14 222	15 061	15 857	16 629	17 388	18 134

Age (in years)	Time (in years) J 100	105	U 110	115	P 120	Q 125	R 130	135	140	145	S 150	155	160	165	170	T 175
0–4	863	817	721	727	853	*920*	915	899	912	962	1 019	1 061	1 089	1 115	1 150	1 196
5–9	829	831	792	703	713	*840*	911	908	894	909	959	1 016	1 057	1 085	1 111	1 147
10–14	804	819	823	785	699	*709*	837	909	906	893	907	957	1 014	1 056	1 084	1 110
15–19	769	795	810	815	780	*695*	706	834	906	905	892	906	956	1 013	1 054	1 082
20–24	720	755	782	800	807	*773*	690	702	831	904	903	890	904	954	1 010	1 052
25–29	664	705	740	770	789	*798*	767	686	699	828	901	900	887	901	951	1 007
30–34	604	648	691	728	759	*781*	791	762	682	696	825	897	897	884	898	947
35–39	543	588	634	678	717	*749*	772	784	756	678	692	820	892	892	879	892
40–44	483	527	574	620	665	*705*	739	763	776	749	672	687	813	885	884	871
45–49	424	466	510	557	604	*650*	691	726	751	766	739	664	677	802	873	872
50–54	358	403	445	489	536	*584*	630	672	702	734	749	723	650	662	785	854
55–59	293	334	377	419	463	*510*	557	604	645	681	708	722	697	626	638	757
60–64	232	265	303	345	385	*429*	474	521	566	607	642	667	681	657	590	602
65–69	172	198	228	264	302	*341*	381	424	468	512	551	582	605	617	596	535
70–74	115	134	157	183	214	*248*	282	318	356	397	435	468	495	514	525	507
75–79	65	78	93	111	131	*155*	182	209	239	271	304	333	358	379	394	402
80–84	30	36	45	54	66	*79*	96	114	132	154	176	197	216	233	246	255
85	10	13	17	22	27	*34*	42	51	63	75	88	102	116	128	139	149
All ages	7 978	8 412	8 742	9 070	9 510	*10 000*	10 463	10 886	11 294	11 721	12 162	12 592	13 004	13 403	13 807	14 237

TABLE V. GROWTH OF POPULATION BY FIVE-YEAR AGE GROUPS, DURING FIVE-YEAR INTERVALS OF TIME, ACCORDING TO MODELS HL, LRVW WX, JUPQ, QRW, AND WX

Age (in years)	Time (in years) H 100	105	110	115	120	L 125	R 130	V 135	140	145	W 150	155	160	165	170	X 175
0–4	888	956	1 020	1 077	1 128	*1 152*	1 117	1 003	965	1 025	1 060	1 055	1 022	995	992	1 002
5–9	780	854	926	994	1 056	*1 107*	1 140	1 109	999	961	1 022	1 056	1 051	1 019	992	990
10–14	698	771	846	919	988	*1 051*	1 103	1 137	1 107	997	960	1 019	1 055	1 050	1 017	991
15–19	623	689	763	838	912	*982*	1 046	1 099	1 134	1 105	996	959	1 018	1 053	1 049	1 016
20–24	554	612	679	753	829	*904*	976	1 041	1 095	1 131	1 103	992	955	1 016	1 051	1 046
25–29	479	541	600	668	743	*821*	897	970	1 036	1 091	1 128	1 098	989	953	1 012	1 047
30–34	405	468	531	591	660	*735*	813	891	965	1 032	1 087	1 122	1 094	985	949	1 008
35–39	343	395	457	521	581	*650*	727	806	885	959	1 026	1 080	1 116	1 088	980	944
40–44	290	333	385	448	511	*572*	642	718	798	876	951	1 016	1 071	1 106	1 079	972
45–49	240	278	322	374	436	*499*	560	630	707	787	861	937	1 003	1 056	1 091	1 064
50–54	198	228	266	309	360	*421*	484	545	614	691	770	845	916	980	1 033	1 067
55–59	163	185	214	250	293	*342*	402	464	523	592	666	742	815	884	946	996
60–64	128	146	168	196	230	*271*	318	375	435	493	558	627	699	768	833	891
65–69	95	110	126	146	172	*203*	241	285	338	393	447	505	569	634	697	756
70–74	63	74	87	101	118	*141*	168	201	239	286	334	379	430	484	539	592
75–79	36	43	52	61	73	*86*	103	125	151	182	219	256	290	329	370	412
80–84	16	20	25	30	36	*44*	53	65	79	97	118	142	166	188	213	240
85	6	7	9	12	15	*19*	23	28	35	44	55	67	81	96	110	125
All ages	6 005	6 712	7 476	8 288	9 136	*10 000*	10 813	11 492	12 105	12 742	13 361	13 897	14 340	14 684	14 953	15 160

Age (in years)	Time (in years) J 100	105	U 110	115	P 120	Q 125	R 130	135	140	145	W 150	155	160	165	170	X 175
0–4	863	817	721	727	853	*920*	915	876	842	841	843	846	851	840	829	823
5–9	829	831	792	703	718	*840*	911	908	872	839	839	840	844	848	838	827
10–14	804	819	823	785	699	*709*	837	909	907	871	838	838	839	843	847	837
15–19	769	795	810	815	780	*695*	706	834	906	905	869	837	836	838	842	846
20–24	720	755	782	800	807	*773*	690	702	831	904	903	867	835	833	836	840
25–29	664	705	740	770	789	*798*	767	686	699	828	901	900	865	832	832	833
30–34	604	648	691	728	759	*781*	791	762	682	696	825	898	897	862	829	828
35–39	543	588	634	678	717	*749*	772	784	756	678	692	820	892	892	856	824
40–44	483	527	574	620	665	*705*	739	763	776	749	672	686	813	885	884	849
45–49	424	466	510	557	604	*650*	691	726	751	766	739	664	677	802	872	872
50–54	358	403	445	489	536	*584*	630	672	707	734	749	723	649	663	785	854
55–59	293	334	377	419	463	*510*	557	604	645	681	708	722	697	626	638	757
60–64	232	265	303	345	385	*429*	474	521	566	607	642	667	680	657	590	602
65–69	172	198	228	264	302	*341*	381	424	469	512	551	582	605	617	596	535
70–74	115	134	157	183	214	*248*	282	318	357	397	435	468	495	514	525	507
75–79	65	78	93	111	131	*155*	182	209	239	271	304	333	358	379	394	401
80–84	30	36	45	54	66	*79*	96	114	133	154	176	198	216	233	246	255
85	10	13	17	22	27	*34*	42	51	63	75	88	102	116	128	139	149
All ages	7 978	8 412	8 742	9 070	9 510	*10 000*	10 463	10 863	11 201	11 508	11 774	11 991	12 165	12 292	12 378	12 439

Appendix C

DETAILED TABLES OF FUTURE POPULATION ESTIMATES FOR THE WORLD, CONTINENTS, REGIONS AND COUNTRIES

TABLE I (A). ESTIMATES OF THE POPULATION OF THE WORLD, CONTINENTS AND REGIONS, 1950–1975, ON HIGH AND LOW ASSUMPTIONS

(In millions, rounded to three significant digits) [a]

		1950	1955	1960	1965	1970	1975
World total	H	2 500	2 690	2 920	3 180	3 500	3 860
	M	...	...	2 910	3 180	3 480	3 830
	L	...	...	2 900	3 120	3 350	3 590
AFRICA							
TOTAL ...	H	199	216	237	263	294	331
	M	...	...	235	256	278	303
	L	...	...	234	254	274	295
Northern Africa	H	42.7	47.3	52.7	59.3	67.1	76.4
	L	...	...	52.3	57.8	63.9	70.4
Middle Africa	H	142	154	168	185	205	230
	L	...	...	165	177	190	202
Southern Africa	H	13.9	15.3	17.0	19.0	21.5	24.4
	L	...	...	16.8	18.6	20.4	22.5
NORTH AMERICA							
TOTAL ...	H	219	240	262	286	311	339
	L	...	...	261	202	303	324
Northern America	H	168	182	197	210	225	240
	L	...	...	196	209	221	232
Central America	H	34.7	40.0	46.3	53.6	62.2	72.3
	L	...	...	45.9	52.3	59.2	66.6
Caribbean	H	16.3	17.8	19.6	21.7	24.2	27.1
	L	...	...	19.4	21.2	23.1	25.1
SOUTH AMERICA							
TOTAL ...	H	112	125	140	158	179	204
	L	...	...	139	154	172	190
Tropical South America	H	84.4	94.6	107	122	140	163
	L	...	...	106	119	134	150
Temperate South America	H	27.2	30.0	32.9	35.8	38.8	41.7
	L	...	...	32.8	35.5	38.1	40.4
ASIA (excluding the Asian part of the Soviet Union)							
TOTAL ...	H	1 380	1 490	1 620	1 780	1 980	2 210
	L	...	...	1 610	1 720	1 890	2 040
South-West Asia	H	63.3	71.6	80.9	91.4	103	116
	L	...	...	80.3	89.3	98.4	107
Central South Asia	H	466	499	542	595	660	737
	L	...	...	538	581	628	680
South-East Asia	H	171	186	204	225	250	280
	L	...	...	202	220	239	259
East Asia (without Japan)	H	595	641	700	771	856	958
	L	...	...	694	752	816	884
Japan and Ryukyu Islands	H	83.6	89.9	96.0	103	110	117
	L	...	...	95.1	99.9	105	110

TABLE I (A). ESTIMATES OF THE POPULATION OF THE WORLD, CONTINENTS AND REGIONS 1950–1975, ON HIGH AND LOW ASSUMPTIONS *(continued)*

		1950	*1955*	*1960*	*1965*	*1970*	*1975*
EUROPE (excluding the European part of the Soviet Union)							
TOTAL ...	H	393	409	424	440	457	476
	L	...	...	423	435	447	458
Northern and Western Europe .	H	133	137	140	144	148	154
	L	...	...	140	143	146	149
Central Europe	H	128	134	140	145	151	156
	L	...	...	140	144	148	151
Southern Europe	H	132	138	144	151	158	166
	L	...	...	143	148	153	158
OCEANIA							
TOTAL ...	H	13.2	14.7	16.3	17.8	19.4	21.0
	L	...	...	16.3	17.7	19.2	20.5
Australia and New Zealand ...	H	10.2	11.5	12.7	13.8	14.9	16.0
	L	...	...	12.6	13.7	14.7	15.5
Pacific Islands		2.93	3.26	3.63	4.04	4.50	5.01
SOVIET UNION (Asian and European parts combined)							
TOTAL ...	H	181	197	215	234	254	275
	L	...	...	214	232	249	266

[a] For the 1950–1975 period, no separate medium assumptions were made in respect of regions, the medium series up to 1975 being identified with the high series for all regions other than Middle Africa, where it is identified as the low series, and the Pacific Islands, where only a single series of estimates has been considered. By adding low figures for Middle Africa to high figures for the other regions, however, separate medium totals are obtained for the African continent, and for the world as a whole. For 1950–1955, the base period, only a single set of estimates applies.

TABLE I (B). ESTIMATES OF THE POPULATION OF THE WORLD, CONTINENTS AND REGIONS, 1975–2000, ON THREE ASSUMPTIONS

(In millions, rounded to three significant digits)

		1975	*1980*	*1985*	*1990*	*1995*	*2000*
World total	H	3 860	4 280	4 770	5 360	6 060	6 900
	M	3 830	4 220	4 660	5 140	5 680	6 280
	L	3 590	3 850	4 110	4 370	4 620	4 880
AFRICA							
TOTAL ...	H	331	375	428	492	569	663
	M	303	333	368	410	459	517
	L	295	318	341	366	393	420
Northern Africa	H	76.4	87.6	101	118	138	162
	M	76.4	87.3	99.5	114	129	147
	L	70.4	77.4	84.9	92.8	101	109
Middle Africa	H	230	259	294	336	388	449
	M	202	217	237	260	289	323
	L	202	215	229	249	260	276
Southern Africa	H	24.4	28.0	32.4	37.7	44.1	51.9
	M	24.4	27.9	31.9	36.3	41.4	47.1
	L	22.5	24.8	27.2	29.7	32.2	34.8
NORTH AMERICA							
TOTAL ...	H	339	370	404	444	490	544
	M	339	369	400	434	471	510
	L	324	344	364	384	403	421
Northern America	H	240	255	271	287	305	326
	M	240	254	269	283	297	312
	L	232	243	252	260	267	274
Central America	H	72.3	84.4	99.1	117	139	166
	M	72.3	84.0	97.4	113	130	150
	L	66.6	74.4	82.9	91.9	101	111
Caribbean	H	27.1	30.6	34.9	39.9	46.0	53.2
	M	27.1	30.5	34.2	38.4	43.0	48.0
	L	25.1	27.3	29.5	31.8	34.0	36.1

TABLE I (B). ESTIMATES OF THE POPULATION OF THE WORLD, CONTINENTS AND REGIONS, 1975–2000, ON THREE ASSUMPTIONS *(continued)*

		1975	*1980*	*1985*	*1990*	*1995*	*2000*
SOUTH AMERICA							
TOTAL ...	H	204	234	271	314	368	432
	M	204	234	266	304	347	394
	L	190	210	231	253	275	298
Tropical South America	H	163	190	223	263	313	374
	M	163	189	219	254	294	339
	L	150	167	186	206	228	249
Temperate South America	H	41.7	44.7	47.8	51.0	54.5	58.2
	M	41.7	44.6	47.4	50.2	53.0	55.8
	L	40.4	42.5	44.4	46.2	47.7	49.1
ASIA (excluding the Asian part of the Soviet Union)							
TOTAL ...	H	2 210	2 480	2 810	3 200	3 680	4 250
	M	2 210	2 470	2 760	3 090	3 460	3 870
	L	2 040	2 200	2 370	2 540	2 720	2 890
South-West Asia	H	116	131	148	170	196	227
	M	116	130	146	164	184	206
	L	107	116	125	135	144	153
Central South Asia	H	737	831	944	1 080	1 240	1 440
	M	737	828	929	1 040	1 170	1 310
	L	680	736	795	855	915	975
South-East Asia	H	280	316	359	410	473	548
	M	280	315	353	396	444	498
	L	259	280	302	325	348	371
East Asia (without Japan)	H	958	1 080	1 230	1 400	1 620	1 870
	M	958	1 080	1 210	1 350	1 520	1 700
	L	884	956	1 030	1 110	1 190	1 270
Japan and Ryukyu Islands ...	H	117	124	133	141	150	159
	M	117	124	132	139	146	153
	L	110	114	118	121	123	125
EUROPE (excluding the European part of the Soviet Union)							
TOTAL ...	H	476	496	517	540	564	592
	M	476	495	514	532	550	568
	L	458	469	477	483	487	491
Northern and Western Europe .	H	154	159	165	172	179	187
	M	154	159	164	169	174	180
	L	149	151	154	155	156	157
Central Europe	H	156	162	168	175	182	191
	M	156	162	167	172	178	183
	L	151	154	156	158	159	160
Southern Europe	H	166	175	184	193	203	214
	M	166	174	182	190	198	206
	L	158	163	167	170	172	174
OCEANIA							
TOTAL ...	H	21.0	22.5	24.2	26.0	28.0	30.2
	M	21.0	22.5	24.1	25.7	27.5	29.3
	L	20.5	21.7	23.0	24.2	25.5	26.8
Australia and New Zealand ...	H	16.0	17.0	18.0	19.1	20.3	21.6
	M	16.0	16.9	17.9	18.8	19.8	20.8
	L	15.5	16.2	16.8	17.3	17.8	18.2
Pacific Islands	H	5.01	5.58	6.21	6.92	7.70	8.57
SOVIET UNION (Asian and European parts combined)							
TOTAL ...	H	275	297	320	344	369	395
	M	275	297	318	339	359	379
	L	266	282	297	311	323	333

TABLE II. ESTIMATES OF THE FUTURE POPULATION OF COUNTRIES, 1955–1975 (ROUNDED TO THOUSANDS, THREE SIGNIFICANT FIGURES MEDIUM ASSUMPTION)

	1955	*1960*	*1965*	*1970*	*1975*
AFRICA					
NORTHERN AFRICA					
Egypt	23 000	26 000	29 500	33 500	38 300
Libya	1 100	1 210	1 340	1 500	1 700
Algeria	9 470	10 400	11 500	13 000	14 700
Ceuta and Melilla	143	149	158	173	195
Morocco	9 730	10 800	12 100	13 600	15 500
Spanish West Africa	83	88	96	106	120
Tunisia	3 740	4 120	4 600	5 180	5 900
MIDDLE AFRICA					
Empire of Ethiopia incl. Eritrea	11 600	12 200	12 800	13 500	14 400
Liberia	1 280	1 320	1 370	1 440	1 520
Sudan	10 100	10 500	10 900	11 500	12 200
Angola	4 280	4 490	4 730	5 000	5 310
Belgian Congo	12 600	13 900	15 200	16 500	17 600
Cameroons (Br. Admin.)	1 500	1 610	1 730	1 850	1 970
Cameroons (Fr. Admin.)	3 150	3 380	3 620	3 860	4 120
Cape Verde Is.	172	193	214	233	251
French Equat. Africa	4 680	4 970	5 290	5 620	5 980
French Somaliland	63	66	69	74	79
French West Africa	19 000	20 200	21 700	23 200	24 700
Gambia	298	309	323	340	360
Ghana	4 620	4 980	5 340	5 720	6 100
Kenya	6 050	6 530	7 020	7 520	8 030
Madagascar and Comoro Is.	4 950	5 430	5 900	6 360	6 810
Mauritius and Dep.	566	649	727	797	855
Mozambique	6 030	6 390	6 780	7 200	7 660
Nigeria	31 300	34 000	36 800	39 600	42 300
Rhodesia and Nyasaland	7 070	7 920	8 730	9 480	10 200
Portuguese Guinea	540	572	606	643	684
Reunion	278	302	326	351	374
Ruanda-Urundi	4 280	4 640	5 000	5 370	5 730
St. Helena and Dep.	5	5	5	5	5
São Tomé and Principe	58	58	58	61	63
Seychelles and Dep.	38	41	44	47	51
Sierra Leone	2 100	2 210	2 330	2 470	2 630
Somaliland (Ital. Admin.)	1 280	1 320	1 370	1 440	1 520
Somaliland Prot.	523	552	582	615	653
Spanish Guinea	207	218	230	245	259
Tanganyika	8 320	8 960	9 620	10 300	11 000
Togoland (Fr. Admin.)	1 080	1 160	1 250	1 340	1 430
Uganda	5 510	5 890	6 290	6 700	7 140
Zanzibar & Pemba	278	289	303	319	338
SOUTHERN AFRICA					
Union of S. Africa	13 700	15 200	17 000	19 200	21 900
Basutoland	627	676	741	827	937
Bechuanaland	328	362	404	455	517
South West Africa	458	520	591	674	770
Swaziland	223	253	288	329	375
AMERICA					
NORTHERN AMERICA					
Canada	15 900	17 600	19 300	20 800	22 300
United States	166 000	179 000	191 000	204 000	217 000
Alaska	208	250	286	319	345
Bermuda	42	47	53	56	60
Greenland	26	28	29	32	34
St. Pierre & Miquelon	5	5	5	5	5

TABLE II. ESTIMATES OF THE FUTURE POPULATION OF COUNTRIES, 1955–1975 (ROUNDED TO THOUSANDS, THREE SIGNIFICANT FIGURES MEDIUM ASSUMPTION) *(continued)*

	1955	*1960*	*1965*	*1970*	*1975*
AMERICA *(continued)*					
CENTRAL AMERICA					
Costa Rica	951	1 120	1 320	1 550	1 810
El Salvador	2 190	2 570	3 000	3 510	4 090
Guatemala	3 260	3 790	4 400	5 120	5 960
Honduras	1 660	1 930	2 250	2 620	3 040
Mexico	29 700	34 200	39 600	45 900	53 300
Nicaragua	1 240	1 460	1 710	1 990	2 320
Panama	910	1 040	1 200	1 390	1 610
British Honduras	79	93	108	126	147
Canal Zone	53	58	64	72	82
CARIBBEAN					
Cuba	6 110	6 810	7 610	8 540	9 600
Dominican Rep.	2 400	2 710	3 060	3 440	3 880
Haiti	3 300	3 560	3 880	4 280	4 790
Bahamas	96	114	133	152	173
Barbados	229	253	280	313	352
Guadeloupe	230	240	255	277	309
Jamaica & Dep.	1 560	1 720	1 910	2 140	2 400
Leeward Is.	128	146	165	187	211
Martinique	240	252	269	294	328
Netherlands Antilles	182	204	230	259	292
Puerto Rico	2 260	2 360	2 520	2 750	3 060
Trinidad & Tobago	721	819	929	1 050	1 180
Virgin Is. (U.S.)	24	25	26	28	31
Windward Is.	313	354	401	452	510
TROPICAL SOUTH AMERICA					
Bolivia	3 190	3 440	3 800	4 270	4 910
Brazil	59 200	67 100	76 700	88 200	102 000
Colombia	12 700	14 300	16 200	18 600	21 600
Ecuador	3 610	4 150	4 790	5 550	6 440
Peru	9 400	10 500	11 800	13 600	15 700
Venezuela	5 830	6 760	7 830	9 100	10 600
British Guiana	484	560	649	753	875
French Guiana	28	30	32	35	41
Surinam	238	261	292	331	382
TEMPERATE SOUTH AMERICA					
Argentina	19 300	21 300	23 200	25 200	27 200
Chile	6 560	7 070	7 610	8 180	8 790
Paraguay	1 560	1 730	1 900	2 070	2 230
Uruguay	2 620	2 830	3 050	3 290	3 530
Falkland Is.	2	2	2	2	2
ASIA					
SOUTH WEST ASIA					
Bahrain	120	132	146	163	182
Iran	21 800	24 300	27 200	30 500	34 300
Iraq	5 730	6 480	7 300	8 220	9 230
Israel	1 750	2 270	2 800	3 310	3 780
Jordan	1 430	1 610	1 820	2 050	2 300
Kuwait	203	222	244	271	304
Lebanon	1 420	1 620	1 830	2 070	2 320
Muscat & Oman	550	560	582	623	687
Qatar	35	41	47	55	61
Saudi Arabia	5 900	6 640	7 490	8 430	9 470
Syria	4 140	4 840	5 590	6 380	7 210
Trucial Oman	80	86	93	102	114
Turkey	24 000	27 500	31 300	35 500	40 000
Yemen	3 000	3 000	3 170	3 400	3 700
Aden Colony	140	183	226	268	306
Aden Protectorate	426	459	500	552	616
Cyprus	532	575	628	694	774
Gaza Strip (Palestine)	325	366	412	464	522

TABLE II. ESTIMATES OF THE FUTURE POPULATION OF COUNTRIES, 1955–1975 (ROUNDED TO THOUSANDS, THREE SIGNIFICANT FIGURES MEDIUM ASSUMPTION) *(continued)*

	1955	*1960*	*1965*	*1970*	*1975*
ASIA *(continued)*					
CENTRAL SOUTH ASIA					
Afghanistan	12 000	12 800	13 800	15 100	16 900
Bhutan	624	689	762	851	951
Ceylon	8 680	9 850	11 100	12 600	14 100
India	386 000	417 000	456 000	504 000	563 000
Maldive Is.	80	76	77	79	88
Nepal	8 600	9 400	10 500	11 600	13 100
Pakistan	83 200	92 200	102 000	114 000	128 000
Portuguese India	644	667	708	765	848
SOUTH EAST ASIA					
Burma	19 400	20 700	22 400	24 600	27 400
Cambodia	4 360	4 720	5 180	5 740	6 410
Indonesia	81 900	89 300	98 300	109 000	122 000
Laos	1 420	1 570	1 750	1 950	2 170
Viet-Nam	26 300	29 100	32 300	36 000	40 400
Thailand	20 500	22 900	25 600	28 600	32 100
Philippines	22 100	24 400	27 200	30 400	34 100
Brunei	65	75	88	100	112
Malaya	6 070	6 990	7 980	9 050	10 200
North Borneo	373	427	486	551	619
Portuguese Timor	469	511	560	621	695
Sarawak	614	678	751	839	939
Singapore	1 250	1 470	1 700	1 940	2 200
W. New Guinea	700	714	749	784	858
EAST ASIA (without Japan)					
China (Mainland)	600 000	654 000	720 000	799 000	894 000
China (Taiwan)	8 910	10 400	12 100	13 800	15 600
Korea	29 000	31 500	34 700	38 400	43 000
Mong. People's Rep.	1 000	1 070	1 160	1 280	1 440
Hong Kong	2 340	2 470	2 660	2 910	3 240
Macao	199	217	239	265	297
JAPAN & RYUKYU ISLANDS					
Japan	89 100	95 100	102 000	109 000	116 000
Ryukyu Is. (U.S.)	800	891	983	1 070	1 150
EUROPE					
NORTHERN & WESTERN EUROPE					
Belgium	8 870	9 090	9 330	9 620	9 961
Denmark	4 470	4 630	4 780	4 950	5 140
Finland	4 240	4 440	4 620	4 800	4 980
France	43 300	44 500	45 900	47 400	49 100
Iceland	157	170	180	190	198
Ireland	2 910	2 870	2 870	2 910	2 990
Luxembourg	309	320	331	343	355
Monaco	20	21	22	22	23
Netherlands	10 800	11 300	11 800	12 300	12 800
Norway	3 420	3 570	3 700	3 850	4 000
Sweden	7 260	7 490	7 730	7 990	8 280
United Kingdom	51 000	51 600	52 400	53 700	55 500
Channel Is.	101	101	101	102	106
Isle of Man	56	59	62	64	66
CENTRAL EUROPE					
Austria	6 970	7 030	7 120	7 280	7 520
Czechoslovakia	13 100	13 700	14 300	14 900	15 500
Germany	71 000	73 000	75 200	77 700	80 500
Hungary	9 800	10 200	10 600	11 100	11 500
Liechtenstein	15	15	16	17	17
Poland	27 300	29 400	31 300	33 000	34 400
Switzerland	4 980	5 230	5 470	5 700	5 920
Saar	992	1 040	1 080	1 120	1 170

TABLE II. ESTIMATES OF THE FUTURE POPULATION OF COUNTRIES, 1955–1975 (ROUNDED TO THOUSANDS, THREE SIGNIFICANT FIGURES MEDIUM ASSUMPTION) *(continued)*

	1955	*1960*	*1965*	*1970*	*1975*
EUROPE *(continued)*					
SOUTHERN EUROPE					
Albania	1 390	1 550	1 690	1 820	1 920
Andorra	5	5	5	5	5
Bulgaria	7 550	7 820	8 150	8 500	8 900
Greece	7 970	8 360	8 780	9 220	9 690
Italy	48 000	49 500	51 300	53 500	56 100
Portugal	8 770	9 120	9 520	9 970	10 500
Romania	17 400	18 500	19 600	20 700	21 700
San Marino	14	14	15	16	17
Spain	29 000	30 000	31 300	32 800	34 400
Yugoslavia	17 700	19 000	20 200	21 400	22 600
Gibraltar	25	24	24	25	27
Malta & Gozo	314	316	323	334	349
OCEANIA AND PACIFIC					
AUSTRALIA AND NEW ZEALAND					
Australia	9 340	10 300	11 200	12 200	13 000
New Zealand	2 150	2 360	2 572	2 780	2 970
PACIFIC ISLANDS					
American Samoa	22	25	29	32	36
Br. Solomon Is.	103	107	114	123	136
Cook Is.	16	17	19	20	23
Fiji Is.	339	392	449	508	568
Fr. Oceania	69	78	87	98	109
Gilbert & Ellice Is.	41	44	49	54	60
Guam	65	72	79	88	98
Hawaii	560	635	716	804	897
Nauru	4	4	4	4	4
New Caledonia	65	68	72	78	86
New Guinea	1 250	1 370	1 510	1 670	1 860
New Hebrides	54	60	66	73	81
Niue	5	5	5	5	5
Pacific Is. (U.S. Admin.)	64	74	84	95	106
Papua	446	497	554	617	793
Tokelau Is.	2	2	2	2	2
Tonga	54	61	68	76	84
W. Samoa	95	112	129	147	165
USSR					
USSR	197 000	215 000	234 000	254 000	275 000