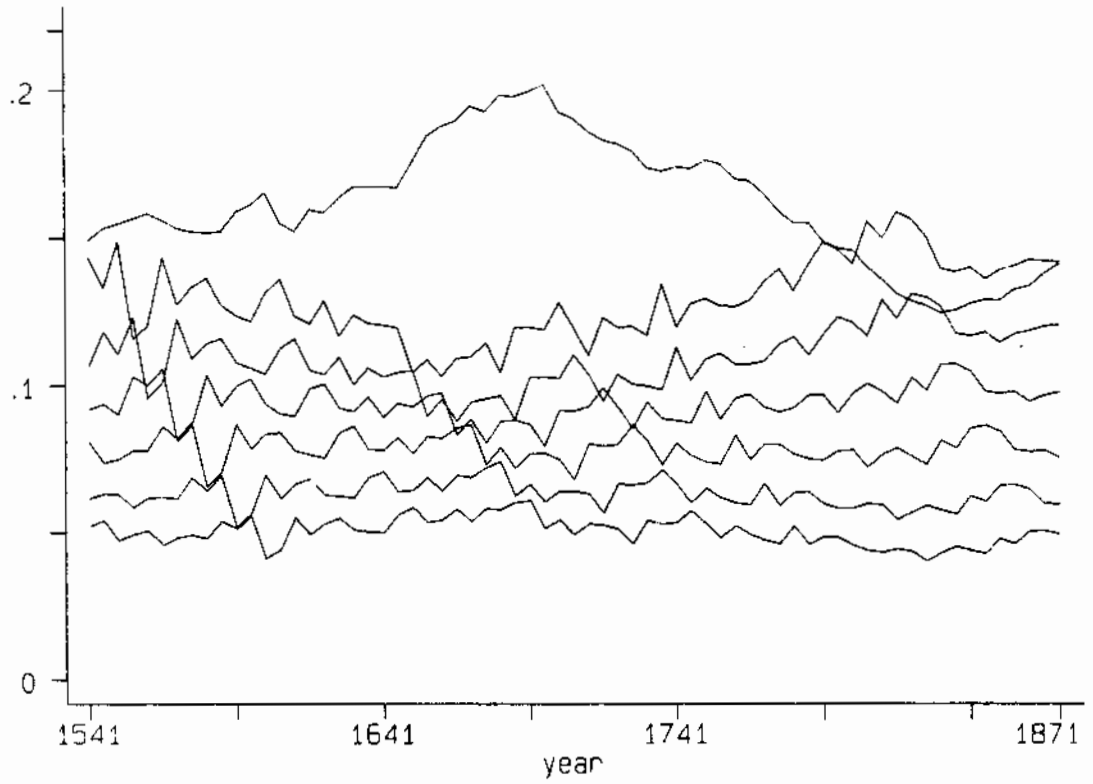
POPULATE

From Births and Deaths to the Demography of the Past, Present, and Future



The Population Age Structure of England, 1541-1871

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POPULATE(c)
From Births and Deaths to the Demography of the Past, Present, and Future

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Install *POPULATE* with *PINSTALL* or *POPHERC*

For all systems, first

Copy *all* files from the *POPULATE* disc to an empty floppy disc, or to a sub-directory of a hard disc. Files for Help (*POPULATE.HLP*), life tables (*POPULATE.LIF*), and installation settings (*POPULATE.INI*) must be readily available on the work disc (or subdirectory); otherwise, a message appears on the screen, and the program stops. The solution: copy all files from the original to the work disc, re-install the program, then *POPULATE*.

Three installation options

POPULATE will run fine with any of three types of systems: text-only, Hercules cards, and conventional PC compatible cards (CGA, EGA, VGA).

Text-only systems

For text-only systems, *POPULATE* is already installed; skip to the section on disc space and projection limits at the end of this chapter.

HERCULES+ systems

These adapter cards shine with *POPULATE*, and installation is also simple: Run *POPHERC*. No further action is necessary. *POPULATE* produces crisp, speedy *HERCULES* graphics, but with two important conditions. First, it is possible that *POPULATE*'s Hercules graphics driver may conflict with other graphics programs. To avoid this, restart or re-boot the computer after quitting *POPULATE*. Also, note that should a conventional adapter be installed, the *HERCULES* settings must be un-installed. When a *HERCULES* card is replaced by a conventional card, run *UNHERC*, then install as follows. Second, with respect to printing, *HERCULES* screen displays do not conform to IBM standards. Printed copies of rough-and-ready graphics are not available in *HERCULES* mode. To obtain printed copy of *POPULATE text* displays, select *O*ptions *C*onfigure *A*dapter *M*dpa (*<ESC> OCAM <ESC>*), then print normally. To return to *HERCULES* mode, select *O*ptions *C*onfigure *A*dapter he*R*cules (*<ESC> OCAR <ESC>*), and continue. This completes installation instructions for *HERCULES* systems. Skip to the section on disc space and projection limits at the end of this chapter.

Conventional graphics systems

For all other graphics adapter cards and monitors, run *PINSTALL*. Make selections from three menus (adapter, background, and graphics color):

1. confirm adapter type by pressing "Y" (Yes) (or experiment with one or more selections from the menu; see *PINSTALL* below)
2. select a background color on color systems, or monochrome for others
3. and, if desired on EGA and VGA systems, set custom colors for graphing *POPULATE*'s statistics.

If the screen display looks fine, tap Q to quit; if not, press I to re-install.

Unknown/troublesome cards

If the system is unknown, don't worry. First, try the three step installation. If the screen fills with streaks (you will not be able to see graphics or read text!), *POPHERC* is needed. Press *Q* (twice) to quit. Then run *POPHERC*. If the sign-on screen graphics look fine, yours is a Hercules adapter and no further installation is needed. If not, quit and run *UNHERC*, then *PINSTALL*. Try to install as a conventional card, selecting options from the adapter menu one at a time. If none produce acceptable

graphics (note the burst of graphics at the left of the sign-on screen), then choose MDPA, by pressing "*M*", and "*Y*"es; the program will produce tables of statistical results, quickly and effortlessly.

Graphs and Lists

For text systems (vintage PCs and monochrome XTs), *POPULATE* computes lists of demographic statistics, but with a graphics card, results are graphed to the screen (and to a dot matrix printer, when desired). Before using *POPULATE*, the program must be tailored to the microcomputer on which it operates. When properly installed, a burst of graphics will radiate--in a rainbow on systems which support advanced colors graphics--from the lower left of the sign-on screen.

Figure 1. Opening Screen

P O P U L A T E(c)

Inverse Projection: Population Rates,
Life Expectancy, Reproduction Ratios,
and Age Structure

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Thanks to Project WOKSAPE
The University of Minnesota
and
International Business Machines Corporation
P O P U L A T E(c)

Version 2.2 February 27, 1989

Press E - England, H - Help, else continue

Pinstall

To install *POPULATE* on a non-*HERCULES* graphics system, run *PINSTALL*. At the first menu, press *I* to install. The installation menu marks the adapter card in your machine with an "!", although some adapters cleverly disguise their true identity. Fortunately, by tapping a few keys, the user can easily experiment with the capabilities of the microcomputer without damaging any hardware.

Select adapter. Press Cga !Ega Mdpa heRcules Loega mOnoega Vga

Press *C*, *E*, *M*, *R*, or *V*, for *C*GA, *E*GA, *M*DPA, he*R*cules and *V*GA, respectively (or *L* or *O* for special varieties of Ega). If yours is a graphics system, but you are in doubt about which kind, search for the optimal configuration by pressing each of the keys in turn. Then press the hotkey of the option that performs best and tap *Yes* to confirm your selection. On high resolution systems, *POPULATE* will tickle as many as 786,432

individual pixels, or as few as 64,000--all automatically set by a selection from the adapter menu.

```
Select !Color Monochrome, else continue
```

Monochrome

Continue installation by selecting Color or Monochrome (monochrome may be desirable for some PCs, XTs or 16 shades of gray systems). Tap C to select color, or M for monochrome. For monochrome systems, installation is completed by pressing <spacebar> to return to the opening screen. At this point, press *I* to re-install, or *Q* to quit.

Tiny, black holes

Selecting "color" for a system which cannot display 16 colors will produce some graphics which are visible only as tiny dark holes. The solution here is to select Monochrome. If color is selected, and the condition appears while *POPULATE* is active, simply select *O*ptions *C*onfigure *M*onochrome (press *<ESC> OCM <ESC>*) and the new settings are automatically installed.

Background Color

On color systems, press C for color, then select a background hue, by pressing any key to view up to 16 colors in succession. The burst of graphics at the lower left of the screen (Figure 1) illustrates how *POPULATE*'s graphics and color will appear. Keep tapping the *<SPACEBAR>*--the prompt will be invisible with some colors--until what you see is what you want. Confirm the selection by pressing *Y*.

Color graphics

Unless you wish to change the default colors for individual statistics on advanced graphics systems (EGA, VGA), installation is now complete. Press *<SPACEBAR>* to skip this section, otherwise a menu appears with the default colors for each statistic.

Rainbow Colors

On an IBM-AT like machine, with an EGA, or VGA card and color monitor, statistics will be displayed in a rainbow effect, each statistic represented by a different color.

```
Statistics:  ■Pop ■Br ■Dr ■Migr ■Grr ■Nrr ■K ■Life ■0q ■Cwr ■Age
Life   A■  B■  C■  D■  E■  F■  G■  I■  J■  K■  M■  O■  P■  R■  S■
```

Color statistics

To change a color from the above menu, press the desired statistic's hotkey (for example, *L* for life expectancy), then choose a color from the displayed palette, by tapping its key (*AB...RS*). When each statistic is colored the way you want, tap *<SPACEBAR>* to return to the main menu.

```
Quit? Press Q again to quit else to continue
```

Finish

Color and graphics installation is now complete. Press *Q* to quit. Neither *PINSTALL* nor *POPHERC* will be needed again unless the computer's adapter card is changed, the initiation file deleted, or a new version of *POPULATE* is installed.

Hardware Requirements:

Most IBM-PC compatibles will work fine with this program, as long as 512k memory is available.

Machine: IBM-PC Compatible 512k memory.

Adapter Card:

Tables: MDPA, CGA, EGA, *HERCULES*, or VGA cards.

Graphics, Color: CGA, EGA, *HERCULES* or VGA.

Printer: graphics: 100% IBM-PC compatible dot-matrix and MDPA-VGA card; any printer for text.

System: MS-DOS 2.0 or higher.

Disc space

POPULATE reads data and automatically writes results to files as projections are made. However automatic filing may be toggled off, by tapping *O*ptions *F*ile. Should disc space become exhausted, the program notes the condition on the screen, and completes the current projection. No further information will be written to disc. To avoid disappointment, have at least 150k available for the results file before starting. Only the tireless modeler will need more than that in a single run.

Projection Limits

The program accommodates up to 640 years of population history with as many as five projections immediately available for display as tables or graphics. When the time series under examination consists of only 150 years, up to thirty projections can be instantaneously examined. When the limit of available computer memory is reached, the program sends a note to the screen, then simply recycles the space allocated to the first model, and projection continues.

Performance:

POPULATE is fast, but its quickness varies according to the speed of the computer's central processor (CPU), disc operations, the number of years being projected (up to 640 years), and the complexity of the model (number of age groups, interpolations, adjustments, etc.). Where a hard disc is not available and filed output is not needed, performance can be improved greatly by not filing results to disc (*O*ption *F*ile *F*ile).

Standard - *The population history of England, 1541-1871*[2]

CPU	Projection time (seconds)
8088 IBM-XT Model 1	60
80286 IBM-AT	26
80286 IBM PS-2/50	16
80386 IBM PS-2/80	8
80386 *SUN* 386i	8

[2] E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541-1871: A Reconstruction*, (Cambridge, Mass: Harvard University Press, 1981), pp. 219, 496-502.

1. Introduction.

Basics

POPULATE is designed to be used with minimal reference to this text. To fully understand both the operation of the program as well as its features and flaws, five sections are developed here:

1. Introduction: Why *POPULATE*, Hotkeys, Help, Common Commands, Speed Populating, and a note on method.
2. Two experiments:
   a. The English demographic revolution, 1541-1871.
   b. How *POPULATE* projects with so few data.
3. Detailed description of each menu, action, and feature.
4. Instructions for preparing data.
5. Glossary: definition of terms, from Active to Zoom.

Before Populating

Before beginning *POPULATE*, always log onto the work disc (A:<*ENTER*>) or subdirectory (C:\Populate<*ENTER*>) so that the program will have ready reference to lifetables (*POPULATE.LIF*), help screens (*POPULATE.HLP*), installation settings (*POPULATE.INI*), data files (xxx.*POP*), etc.

Features

Why POPULATE?

What can counts of births and deaths reveal about life expectancy, fertility, age structure or population size? A lot with *POPULATE*. *POPULATE* computes population size, life expectancy, reproduction ratios, and even age structure, when estimates of births and deaths are the only data at hand. Based on Ronald Lee's inverse method of population projection,[3] *POPULATE* uses real data--whenever possible--and fills in with information from models--when necessary--to compute population censuses at five year intervals. Once a projection is complete, the program makes it possible to quickly construct alternative scenarios to query: what if...conditions were different? *POPULATE* answers with sets of demographic estimates enticed from a time series of births and deaths under varying assumptions--all easily specified according to what you know or are willing to guess.

Uncertainty and flexibility

Lee's method of projection requires that assumptions be made about the size of the initial population and its age and mortality structure, although not its level. *POPULATE* makes possible the rapid re-examination of estimates by varying one or all of the assumptions, as well as taking into account migration, birth or death under-registration, and age-specific patterns of fertility or migration. Thus, where knowledge is uncertain--the case for most places before 1900 and after, say, 1995--this approach "sacrifices" extreme accuracy for flexibility. Students use the program to develop an understanding of population dynamics, to assess the effects of counter factuals, or even project populations into the future under various scenarios. Researchers turn to *POPULATE* to compute consistent

[3] R. Lee, "Inverse Projection and Back Projection: Comparative Results and Sensitivity Tests For England," *Population Studies*, 39 (1985) 233-248; "Estimating Series of Vital Rates and Age Structures from Baptisms and Burials: A New Technique with Applications to Pre-industrial England", *Population Studies*, 28 (1974) 495-512; and *Econometric Studies of Topics in Demographic History* (New York: Arno Press, 1978). For a discussion in Spanish with applications to Latin American populations see: Héctor Perez Brignoli, "Nuevas Perspectivas de la Demografía Histórica en América Latina", *Latin American Population History Newsletter*, No. 12, Fall 1986.

estimates, test data accuracy, and weigh alternative hypotheses about demographic densities and structures.

Demographic snapshots of the past. With *POPULATE*, the historian can select among estimates of population size and structure or mortality and fertility regimes to bring a larger picture into focus, expose inconsistencies, and measure the fragility of the results. *POPULATE* helps reveal the impossible and provides the tools for making all settings consistent. When the entire picture does not add up, the program's demographics help find out why or why not.

Demographics of the future? Demographers project, but do not predict. *POPULATE* does not predict either, but it does allow futurologists--licensed or not--to specify a set of conditions to see what the world or a piece of it might look like. Authorities often present a single demographic view of the future. This program allows *you* to imagine what the setting might be, then project to see what difference it might make. When specialists harness sophisticated tools to simple, politically inoffensive, or plainly unrealistic projections, the non-specialist may turn to *POPULATE*, trading technical sophistication for simplicity, the inoffensive for intuition, inquisitiveness and intelligence.

Tutorials are included with the program. Use them to become familiar with *POPULATE*'s features. New lessons are easily created by simply turning the recorder on and putting the program through its paces. The recordings are saved to disc with the corresponding dataset and are automatically recalled to aid the student in analyzing specific demographic issues.

Structure

Menus The program is completely menu driven. To activate a command or select a feature, simply tap the first letter (hotkey) of words appearing on the command line at the bottom of the screen. Descriptive command names help the beginner or infrequent user to obtain results easily. The opening screen (Figure 1) offers three choices. Press "E" to begin a demonstration using data for England (1541-1871), tap "H" for Help, that is an introduction to *POPULATE*, or strike any other key to continue to the next prompt.

Press E - England, H - Help, else continue

Vocabulary The program's vocabulary is limited to 45 words and three types of commands: actions, display options, and statistics (Figure 2). The essential meaning of each word is summarized in this introduction and may be reviewed on the program's help screens. Chapters 3 and 4, "Composing Models" and "Displays", describe each in context, and Chapter 7, "Glossary", briefly defines them in alphabetical order.

Figure 2. Program Vocabulary

Actions	Display Options	Statistics
<ENTER>	Axis	Age (%)
<ESCAPE>	Chart	Birth rate
<SPACEBAR>	Configure	Child/woman ratio
Continue	File	Death rate
Edit	Graphics	Gross reproduction ratio
Help	Learn	Grouped ages (%)
If	Models	Infant mortality rate
If Age	Note	K (mortality variation)
If Constant	Print screen	Life expectancy at birth
If Lifetable	Restore	Net migration rate
If Variable	Statistics	Net reproduction ratio
Options	Tables	Sum ages (cumulative %)
Pause	View	Total population
Populate	Wipe	
Quit	Zoom	
Record		
Toggle		

Automatic settings

All display and computing conditions are automatically set. The curious projectionist may customize colors, axes, and displays by stroking a few keys from the corresponding menus. Moreover, the program recalls the custom environment, so that in subsequent sessions, conditions are set from the start exactly the way they were left.

Three core menus

The core of the program centers on three menus--Main, Options, If--each containing 8-10 commands. Commands unique to a single menu begin with the letters C, A, or P (italicized below). All other commands are common to the core menus.

a. Common commands (invoked from two or more core menus: Main, Options, or If):

File Graphics Help If Learn Models Note Options Quit Record Statistics Tables View Wipe Zoom

b. Main (*POPULATE*) menu:

Populate Graphics Tables IF *Chart* Help Learn Note Options View Wipe Quit

c. Options menu:

Options Graphics Tables File Record *Axis Configure* Models Statistics View Zoom

d. Models are defined by making selections from the If menu.

If *Age Constant Lifetable Variable* Quit Help

Hotkeys

To activate a command, press its hotkey, the first (capital) letter of its name. If the command is an action (example: *POPULATE*), pressing its key (either lower or upper case) immediately executes (e.g., pressing "P" at the main menu, projects the next model). If the command is a condition (or option), the feature is toggled on or off. "!" indicates that a condition is on; "." that it is off. Tap the corresponding hotkey to activate or toggle the command. The distinction between upper and lower case hotkeys becomes important only when the number of variables at hand exceeds 31, and then only on the "dessert" menu, listing variable names. Thus, for everyone expect the relentless projectionist, there is no difference between upper and lower case hotkeys.

Help

When in doubt, press H for help. A context-specific description of each menu and its commands is available by simply pressing *H*.

Help menu

Press *H* again to obtain a description of each help command (Figure 3). Examine any of the help commands listed by tapping the first letter of a help word. To return to the main menu, tap the <*ESC*> key. To skip over the current help screen press <*TAB*>. To view a different help screen tap the first letter of a help key word (Figure 3; remember the silly little ditty, Poblar Mexico + Gvd Styf **$**, loosely translated as populate Mexico with good stiff pesos).

Figure 3. Help Menu

Populate - Demographic modeling with minimal data and "What-Ifs?"
Options - File Record Axis Configure Menu Statistics View
Basics - Populate menu
Learn - Populate with a tutor (Experiment mode)
Adjust - If Age, Constant, Lifetable, or Variable
Results - filed to disc, suitable for further analysis
Memory - allocations for models and adjustments
Edit - Use the point-and-press editor to modify quinquennial or age variables
Xample - Example data file (see Populate disc): England.pop
IF - If modeling assumptions (births, mortality, ages) were different, ...?
Chart - Charts screen graphics to dot matrix printer
+Database - Populate data for 32 Countries and Communities
Graph - Quinquennial population statistics quickly graphed to the screen
View - Graphics, Tables, Zoom, and other display features
Data - Three simple data input rules
Statistics - for each quinquennium defined
Teach - Prepare lessons for a student or assistant
Ynstall - Install Populate for your monitor and adapter card
Files - Data are read from filename.[pop]; results written to filename.[out]
$ - Thanks for your interest and to

9 Universal keys

The following commands may be activated at any menu: *<ESC>*, *<SPACEBAR>*, *Help*, *Note*, *Quit*, *Wipe*, {*<CTRL>* *<SHIFT>* *<PRINT SCREEN>*}, *<!>*, and *<\>*.

<ESC> - escape directly to the main menu.

<SPACEBAR> - space one step toward the main menu.

H - help.

N - type a note, comments or reactions to findings or whatever at almost any moment (except when editing or calculating). Notes are filed with the statistical results from each model.

Q - Quit.

W - Wipe the screen, when it becomes cluttered.

{*<CTRL>* *<SHIFT>* *<PRINT SCREEN>*} - print text from any screen; depress the *<CONTROL>* and *<SHIFT>* keys simultaneously, then strike the *<PRINT SCREEN>* key. If the printer is on and properly connected, all text on the screen will be printed to paper. (Hercules users see "Print" in glossary.)

<!> - begin a lesson (and record keystrokes in a *.LRN* file), tap *!*. Tapping *!* again, stops the recorder to end the lesson.

<\> - pause the lesson (or recorder), press \ again to restart.

15 common commands (and hotkeys)

The following commands, and their corresponding hotkeys, are common to core menus:

File - write statistics to the results file (toggle on or off).

Graphics - turn graphics on or off (not available on text systems).

Help - explain the current screen.

If - define a scenario for the next projection.

Learn - select a tutorial from the menu of available lessons.

Models - list the conditions which produced each projection (when there is more than 1 model).

Note - write a note to the results file.

Options - change screen display settings (axis, colors).

Quit - quit Populate; return to the operating system.

Record - when on, save each keystroke and comment to the *XXX.LRN* file for use as a tutorial in a subsequent session; *R* or *<!>* also toggles the recorder on/off; *<\>* pauses; press *<\>* again to restart the recorder.

Statistics - select demographic statistics to be displayed.

Tables - turn tables on or off.

View - choose a model to display statistics on the screen for a selected model.

Wipe - wipe the screen of all graphics and text.

Zoom - display statistics for selected years at specified intervals.

Unique keys

There are three keys (*CAP*) on each menu which invoke commands specific to that menu. *P* is reserved to *POPULATE*.

Populate (main) menu:

Chart - chart graphics to paper

Populate - project the current model

Options menu:
- Axis - change the vertical axis of any statistic
- Configure - reconfigure adapter, background and/or graphics colors for statistics

If menu (these commands are invoked only from this menu):
- Age - change age structures for a specific period
- Constant - change initial population size or birth, death or migration rates by a specific factor for an entire projection
- Lifetable - select a mortality or age structure from the set of lifetables
- Variable - change the values for a selected variable at a specific moment

Unassigned keys=continue

When an unassigned key or <*SPACEBAR*> is pressed, the cursor moves one step toward the main menu. The phrase "else continue" means strike <*SPACEBAR*> or an unassigned key to move toward the main menu.

Enter key

When a prompt requests that a response be entered, key some data then press <*ENTER*>. In any instance where data are requested, the program will not continue, until <*ENTER*> or <*RETURN*> is pressed. Pressing <enter> with no data causes default values to be inserted. When in doubt, press enter.

Results/Color

For each projection, *POPULATE* computes the following statistics at five year intervals (defined in Chapter 3; the default color on EGA and VGA systems is italicized):

total population	*rose*
annual crude birth rate	*blue*
annual crude death rate	*green*
annual net migration rate	*yellow*
gross reproduction ratio	*dark green*
net reproduction ratio	*white*
index of mortality variability	*orange*
life expectancy at birth	*pink*
infant mortality rate	*dark red*
child/woman ratio	*brown*
age structure	*dark blue, purple, ...*
cumulate age distribution	*rainbow*

Speed Populating

A speedy way to learn the program is to start it up (after installing, if necessary, with *PINSTALL* or *POPHERC*, type *POPULATE*), select England at the opening screen (press *E*), and, after the projection is complete, play with the menus for 5-10 minutes, simply tapping each key on each menu to see what happens. When in doubt, press <*SPACEBAR*> or <*ENTER*>. All commands are single word mnemonic prompts, most of which are common to demography or nice word processors. There are no obscure or arbitrary control key sequences, nor natterings about cautions, errors, or mistakes. When you change your mind, tap a couple of keys to change the conditions, whether it is a matter of statistics to be viewed, a model to be projected, or the way color or graphics are displayed on the computer screen.

There are no "wrong" keystrokes or conditions. *POPULATE* allows you to define what is possible or impossible, whether it is a matter of negative

population size, infinite life expectancy, or zero birth rate. This flexibility or resilience is a matter of design, to encourage experimentation both with data and the study of populations.

A note on method

POPULATE is based on Lee's inverse projection method, but developed independently of his program, *INVERSE*. *POPULATE* will not exactly replicate results from *INVERSE*. Nevertheless, estimates from both programs are remarkably similar. Moreover, *POPULATE* produces estimates that uncannily parallel results from:

1. back-projection methods developed by E. A. Wrigley and R. Schofield in their path-breaking investigation of English population history
2. demographic rates for better documented places and periods
3. projections by the World Bank and other authorities.

Silly results

Careful study of Lee's method is necessary to appreciate fully its strengths and weaknesses.[4] Silly assumptions produce silly results. The cautious projectionist will distinguish the silly from the sound. Thus, *POPULATE* accommodates not only ZPG (zero population growth) but also ZB or ZD (zero births or zero deaths)! Faulty data or suppositions may be readily exposed by a single *If*. Sound data and reasonable assumptions should lead to insights on the basic demography of the past (and perhaps beyond--try *USA.POP* to peer into America's demographic future).

Features

The advantage of *POPULATE* is that it is fast and flexible. To adapt Lee's method to microcomputers, extreme accuracy is sacrificed for speed and flexibility. *POPULATE*'s projection algorithm is not as strong as Lee's nor is it as computationally accurate. While 512k microcomputers remain the standard, *POPULATE* is restricted to six digits for results (14 for computations). Nevertheless, within these limitations, *POPULATE* manages the population history of England from 1541 to 1871 with a very great number of models (unlimited when results are stored exclusively in computer memory) each made up of a complex variety of assumptions. Moreover the results of any of a dozen projections can be displayed instantly on the computer screen. Graphics or tables may be transferred to paper with a few menu-prompted key strokes. Presentation quality graphics are easily prepared from a results file with standard microcomputer software (*STATA*, *SPSSPC*$^{+}$, *MS-CHART*, etc.).

[4] See footnote 3 for Lee's most important publications on the subject.

2. Two Experiments

The following experiments display the features of the program and the power of the inverse method, but they also reveal the contours of the English demographic revolution and the cornerstone of the science of demography.

England, 1541-1871

The first examines the English demographic revolution (1740-1840) using the birth and death series developed by the Cambridge Group for the History of Population and Social Structure. The authors, E. A. Wrigley and Roger Schofield, convincingly argue that the population of England barely doubled from 1541 to 1741. In the following century, a major demographic shift occurred, causing England's population to triple and continue to grow rapidly for several decades. The debate over the causes of the modern rise of the English population has fascinated historians, medical doctors, and others for some time.[5] *POPULATE* allows you to consider the various hypotheses and muse over the question yourself.

Figure 4. The Peopling of England 1541-1871

England Wrigley & Schofield's data + Lee's pxes 1539 - 1873

	A	Births	Deaths	MigrW+S	Age	Bear31	Lxlee	Migrage
	Pop		Br	Dr		Nrr		Life
1541	2782		39	29		1.28		34.3
1561	3046		34	32		1.03		30.1
1581	3616		34	22		1.38		45.8
1601	4078		34	25		1.26		39.7
1621	4674		33	24		1.26		41.3
1641	5125		32	28		1.09		34.9
1661	5186		27	26		.91		36.6
1681	4996		30	35		.87		29.3
1701	5109		33	26		1.22		38.5
1721	5405		33	31		1.09		33.1
1741	5565		33	32		1.04		31.7
1761	6160		34	29		1.20		35.1
1781	7067		35	29		1.26		35.1
1801	8723		37	27		1.41		37.2
1821	11584		40	24		1.65		42.1
1841	15077		36	22		1.40		43.9
1861	19042		36	22		1.45		45.5
1871	21647		36	22		1.50		45.7

England.pop

Type *POPULATE* to start the program. At the first prompt, press *E* to analyze the English data. If the program indicates that the file *ENGLAND.POP* is not available, press *Q* to Quit, then use operating system commands to find the file.

While calculations are taking place, a title and specifications of the current model, are displayed at the top of the screen, and the year and projected population at the bottom.

[5] Wrigley and Schofield succinctly summarize the controversy on p. 228, ff.

Populating. . .1541 2724

In about a minute (or as little as 10 seconds on a fast microcomputer--the timer at the bottom tells, but disappears when any key is pressed), three hundred years of English population history, marked at quarter century intervals, will appear: total population, crude birth and death rates, net reproduction ratio, and life expectancy at birth (Figure 4). Once the statistical results are displayed on the screen, go to the *POPULATE* menu by tapping any key.

The English demographic revolution, reconsidered. The debate centers on the role of changing vital rates. Was this early modern population explosion, which lasted from 1761 to 1871, due to a decline in death rates or rising birth rates? To test the various explanations, alternative birth and death series can be brought into play (press Learn A to do the experiment as a tutorial). The baseline, Model a, must be revised to take into account estimated migration *rates*, instead of *counts* (a close approximation of a, Model b). Activating the rate variable, forces the level of migration to remain the same throughout the experiment. The experiment proceeds by first varying death, then birth, rates to observe the effect on total population. Thus, three additional models are required: c, the "no revolution" model with constant mortality and fertility; d, mortality, with death rates following their observed course but fertility held constant at its early modern norm; and e, fertility follows its historical course and mortality held constant. For the moment the interplay between rates will be ignored.

Experiment 1.
The English Demographic Revolution: Driven by Mortality or Fertility?

Model	Birth Rates	Death Rates	Keystrokes
b Baseline	Observed	Observed	*IVFKM<ESC>*P
c No revolution	Constant	Constant	*IVIJ<ESC>*P
d Mortality	Constant	Observed	*IVM<ESC>*P
e Fertility	Observed	Constant	*IVIK<ESC>*P

Composing models. To compose model b, press *I*f *V*ariables to examine the menu of variables available for the analysis. Toggle the migration *rate* variable, "Migrlee" on (*F* on the variable menu), as well as the observed birth and death *rate* variables (*KM*). Escape to the main menu (press *<ESC>*), and project model b (press P, name the model " Base"). When computations are complete, compare model a and b to observe their strong similarities. The small differences are due to two changes: first, the use of midpoint birth and death rates generated by *POPULATE* in a previous session and then re-cycled here, and second, switching from Wrigley and Schofield's estimated net migration counts to Lee's hypothesized long swings in out-migration (.0015 per annum 1539-1693, .00085 for 1694-1798, from .0002 to .0014 for 1799 to 1863, then to .001 in 1871).

Models c, d, e

Continue the experiment by constructing models c (*If* Variable *I*bcnst *J*dcnst <*ESC*> *POPULATE* Norev), d (*If* Variable *M*dobsrvd <*ESC*> *POPULATE* Morta), and e (*If* Variable *J*dcnst *K*bobsrvd <*ESC*> *POPULATE* Ferti). Now *V*iew *L*ist models *ABCDE* <*SPACEBAR*> and select the statistic total *P*opulation (Figure 5).

Figure 5. Total Population Estimated by 5 Models
A - Initial, B - Baseline, C - No revolution,
D - Mortality, E - Fertility

England Wrigley & Schofield's data + Lee's pxes 1539 - 1873
A Births Deaths MigrW+S Age Bear31 Lxlee Migrage

Pop	A	Bbase	Cnorev	Dmorta	Eferti
1541	2782	2780	2780	2780	2780
1561	3046	3032	3032	3203	3032
1581	3616	3584	3584	3584	3584
1601	4078	4062	4062	4062	4062
1621	4674	4643	4643	4643	4643
1641	5125	5056	5056	5056	5056
1661	5186	5179	5179	5179	5179
1681	4996	5011	5011	5011	5011
1701	5109	5076	5076	5076	5076
1721	5405	5384	5384	5384	5384
1741	5565	5553	5553	5553	5553
1761	6160	6161	6161	6161	6161
1781	7067	7075	6687	6700	7064
1801	8723	8671	7252	7325	8630
1821	11584	11588	7935	8305	11099
1841	15077	15189	8624	9956	13353
1861	19042	19221	9291	11834	15417
1871	21647	21801	9642	12900	16604

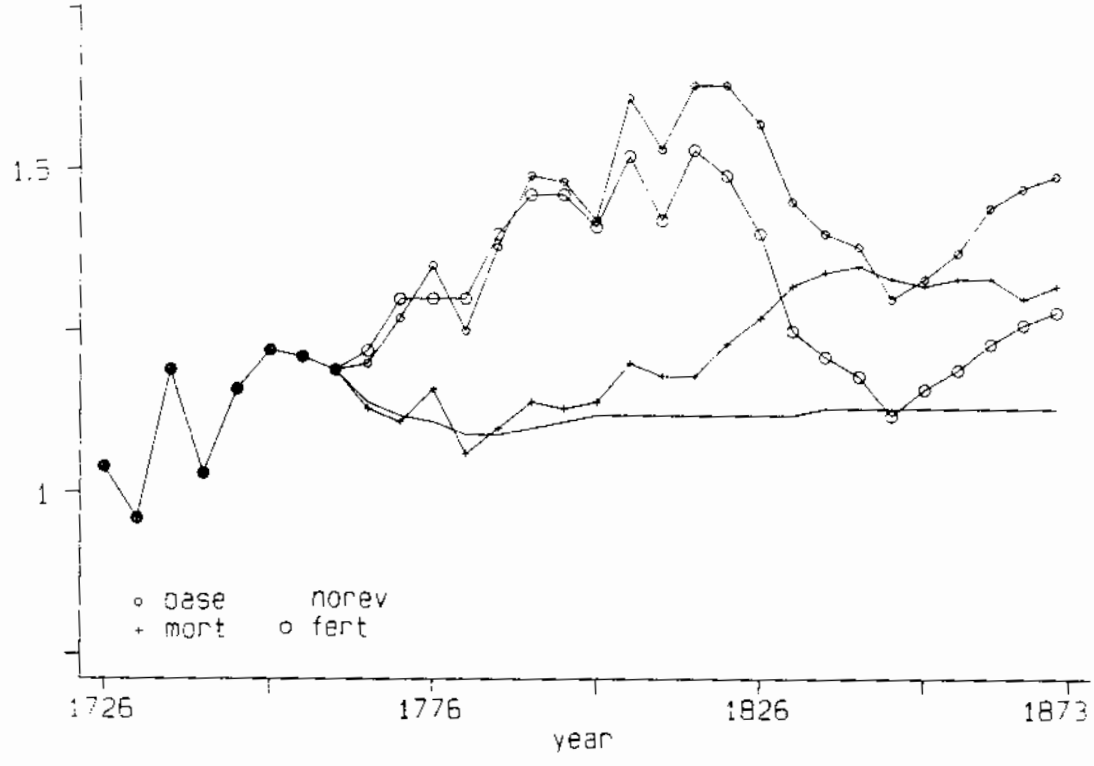
England's late 18th century baby boom and early nineteenth century falling death rates. What would the English population have looked like, if vital rates had continued along the path of the two preceding centuries? Model c shows that there would have been no revolution, that in 1871 the population of England would have stood at less than 10 million, instead of almost 22. Models d and e suggest that both changing death and birth rates accounted for the unprecedented surge in population, but that the fertility effect (6+ million) was more than twice as great as that of mortality (3 million). The unaccounted 2+ millions might be attributed to mortality decline (rising fertility increases mortality where infant deaths constitute a substantial fraction of total deaths) or interaction between both factors.

Net reproduction rate

The most telling evidence is given by the net reproduction rate, which measures actual reproductive performance by taking both mortality and fertility into account (Figure 6; to view on the screen select: *G*raphics or *T*ables, *S*tatistics toggle off all variables except *N*rr, then *V*iew *BCDE*). From 1766 to 1816, the fertility model closely tracks the growth rate of the baseline model. During the first half century of England's

population revolution, the generational growth rate rose steadily. For the next half century (1816-1866), reproduction remained high, but the conditions for growth shifted from rising birth rates to falling death rates (model b and d). This experiment supports Wrigley and Schofield's conclusion that the rise in fertility was the most significant factor and that it preceded mortality decline by at least a quarter century. For the half century from 1766 to 1816, fertility change accounted for 90% of the demographic revolution.

Figure 6. Net Generational Growth Rates (Nrr) Estimated by 4 Models
B - Baseline, C - No revolution, D - Mortality, E - Fertility



It would be misleading to conclude the story here, without examining the series in detail (five year intervals instead of twenty-five) or taking into account exogenous variables such as real wages, passion between the sexes, urbanization, and the like. *POPULATE* offers a solution to the former (from the main menu, press *Zoom 1761 <ENTER> 1841 <ENTER> 5 <ENTER>* to focus on the critical period and set the interval between observations at five years). For the latter, information outside this dataset is required. Wrigley and Schofield, in the concluding chapter of *The Population History of England, 1541-1871: A Reconstruction*, carefully delineate the structural shifts which occurred in English demographic behavior.

Experiment 2: Vital rates, not initial states

Inverse projection

The second experiment examines the methodological underpinnings of inverse projection. Lee called his approach "inverse", because, rather than starting with the "best" data that one has and "projecting" back into the remote past as Wrigley and Schofield did in their ingenious, path breaking study of England, he inverted their procedure, beginning in the distant past and projecting forward, using more or less arbitrary assumptions about initial age and mortality patterns.

Why age structure is important.

What difference does age structure make? None at all, when the issue is total population size or crude rates. But advances in the debate over the demographic determinants of the modern rise of English population require more refined measures of mortality (life expectancy) and fertility (gross reproduction ratio), which in turn depend upon age structure. In the absence of a national census, two methods are available for estimating age structure and age dependent demographic measures from simple counts of births and deaths: back projection and inverse projection.

Back projection

Wrigley and Schofield sought to exploit the earliest known, best age structure of the English population, that from the census of 1871, and work their way back as far as baptismal and burial registers permit, to 1541. Thus every hump and bump of the 1871 population pyramid of England became their starting point. Counts for ages at which reporting is notoriously inaccurate--75-79, 80-84, even 85-89--are critical for their method. Put simply and without consideration of the many cunning uses of computers and demographic theory, they projected the English population backward, by subtracting births from the base of the pyramid, adding deaths to the various age groups along its slope and creating a new peak. This essentially shoved the pyramid down a layer, that is, back five years. Back projections were repeated 65 times at five year intervals to arrive at an estimate of the age pyramid for 1541. Moreover many iterations, or sets of projections, were made to extract the single set which best satisfied complex statistical and demographic tests. By means of much energy and imagination, the Cambridge Group constructed a landmark series of demographic statistics at five year intervals, including estimates of life expectancy, fertility, and even population age structure stretching over a period of more than three centuries.

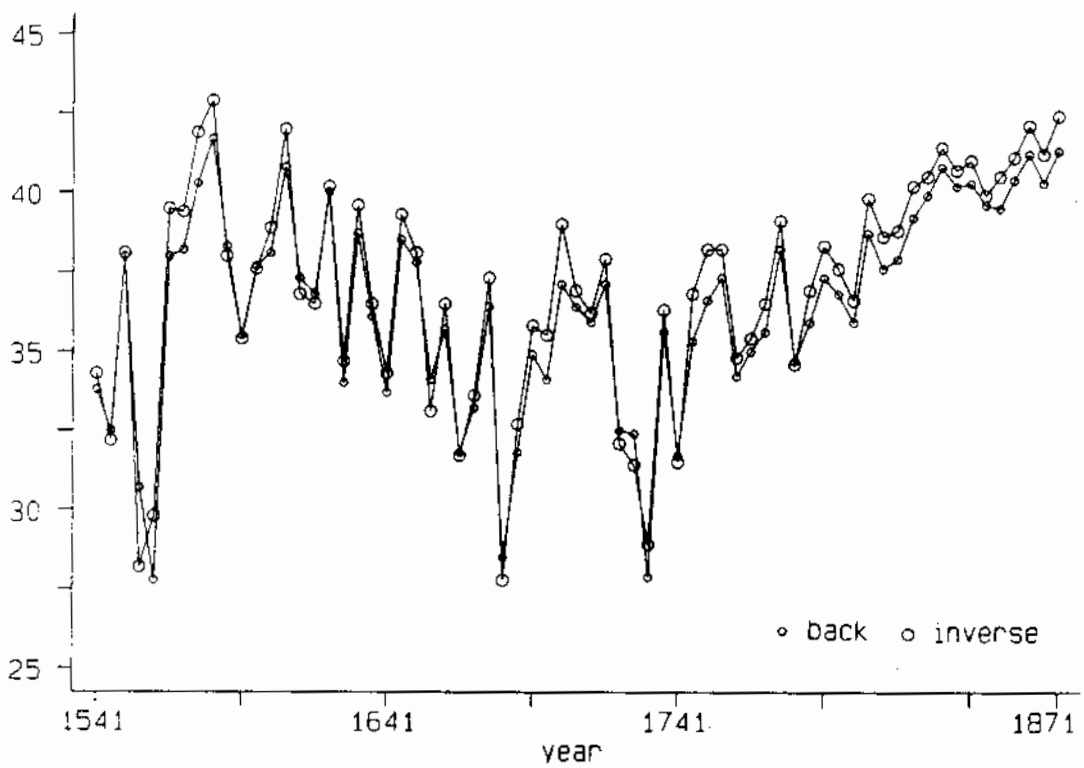
Inverse projection

Lee questions the theoretical underpinnings of back projection. He argued that the concern with initial states, the age structure of England in 1871, is misplaced, that vital rates, birth and death series, are the critical factors. The foundations of inverse projection lie in the 1920s with the work of H. T. J. Norton on the weak ergodicity theorem and its rediscovery by Alvaro Lopez in 1961. It rests on what Kenneth Wachter has called "the cornerstone of formal demography", the notion that, in the long run, vital rates, not initial states, determine what a population will look like.[6] Lee noted that populations rapidly "forget" their age structure, even following substantial mortality or fertility fluctuations (Lee, 1985:234). Two conclusions immediately follow. First, Wrigley and Schofield's concern with empirically derived starting assumptions may not be as critical as they assumed. Secondly, the effects of more or less arbitrary assumptions necessary to initiate an inverse projection vanish rather quickly (say, in a half century) and with hardly a trace. *POPULATE* makes it possible to quickly and easily conduct an experiment to judge the merits of Lee's argument.

Inverse vs. back projection

Figure 7 compares back projection estimates of life expectancy of England with the results from Model A. The figure shows that inverse projection produces estimates that are almost identical to back projection, when the hypothesized initial states are more or less reasonable. What is reasonable?

Figure 7. Life Expectancy from Back and Inverse Projections, England 1541-1871



[6] K. W. Wachter, "Ergodicity and Inverse Projection", *Population Studies*, 40(1986), 278; the jingle is on page 275.

A test of the weak ergodicity theorem. Consider what happens to estimates of mortality and fertility when different, even highly unlikely, assumptions are made. The baseline is Figure 4 (above, to view on screen, press *View A*), that is, the age structure and mortality levels for England from 1541 to 1871, using the Cambridge Group's data and assumptions.

Experiment 2.
Vital Rates versus Initial States

Model (Initial States)	Region	Life Expectancy	Growth Rate	Keystrokes
a Baseline	-	33.8	.8	-
f Close guess	West	37.5	.8	*ILWI8<ESC>P*
g Low mortality	West	57.5	.8	*ILWT8<ESC>P*
i High fertility	West	37.5	2.0	*ILWI20<ESC>P*

Model f, an approximation. Model f, with mortality and age structure characteristic of a "West" population with life expectancy at birth of 37.5 years and growth rate of .8% per annum, attempts to approximate, without duplicating, the baseline from the set of 192 life tables available in *POPULATE*. Models g and i are designed to answer the question: What happens if even absurd age and mortality suppositions are made? Model g uses life chances more characteristic of the twentieth century than the sixteenth (57.5 years; the life expectancy in Britain at the beginning of the twentieth century stood at 48 years). Model i hypothesizes twentieth century fertility characteristic of, say, Latin America in the 1940s. Each model can be specified and projected with a half dozen mnemonically prompted keystrokes. The entire experiment can be conducted by pressing *L* to activate Learn, then selecting lesson "*B*", and following instructions as they appear above the command line at the bottom of the screen. The following supplements the instructions in lesson b.

Testing Lee's hypothesis. First, set the conditions for model f. Press *I* to turn to the *I*f menu, then *L* to access *L*ifetables, *W* for region *W*est, *I* to access the 37.5 model life table, then type *8 <ENTER>* to generate the age structure of a "western" population with a life expectancy at birth of 37.5 years and a rate of natural increase of 0.8% per annum. The variables "Lw37" and "A37r8" are activated (signaled by a "!" in the variable menu at the top of the screen). This assigns to the population of England in 1541 the age structure of a moderately growing "western" population and a western age pattern of dying with a life expectancy at birth of 37.5 years. Note that previous age and mortality conditions ("Lxlee" and "Agew+s") automatically become inactive when new conditions are set. Select "Migrate" (tap *E*) to re-activate Wrigley and Schofield's estimates of net migration. Tap *<ESC>* to regain the main menu, then press *P* to *POPULATE*. Name the model (e.g., "Close") and compute. The identification of the model at the top of the screen includes "LW37" for survival probabilities from model life table West 37.5, and "AW37r8" for the age structure from the same life table with a growth rate of 8 per thousand.

When computations for model f finish, instead of pausing to compare it with model a, quickly specify and project model g (*If Lifetable West T8<ESC> POPULATE* Lodth), and i (*If Lifetable West I20<ESC> POPULATE* Hibir).

Results

from these models demonstrate the power of Lee's method. First, reset the Zoom feature to focus on the period 1541-1621 (*Z1541<ENTER>1621<ENTER>5<ENTER>*). To compare say, life expectancy, press *View*, *List* model *AFGI<SPACEBAR>*, *Life* expectancy (press *VLAFGI<SPACEBAR>L*). The tabular display (Figure 8) shows that by 1591, the largest divergence in life expectancy at birth between model a and the others is less than one year! This is a trivial difference indeed, considering the enormous difficulties in constructing the data on which Wrigley and Schofield's estimates are based.

Figure 8. Life Expectancy From Four Models:
A - W+S, F - Close, G - Low mortality, I - High fertility

England Wrigley & Schofield's data + Lee's pxes 1539 - 1873
Single Statistic displayed for various models and years

Life	A	Glodth	FClose	IHirni
1541	34.3	37.4	34.5	32.2
1561	30.1	30.6	29.6	28.2
1581	45.8	42.6	43.0	43.1
1601	39.7	38.8	38.9	39.1
1621	41.3	40.2	40.1	40.0
1641	34.9	34.4	34.4	34.4
1661	36.6	36.5	36.5	36.6
1681	29.3	28.1	28.1	28.1
1701	38.5	38.9	38.9	38.9
1721	33.1	32.3	32.3	32.3
1741	31.7	31.5	31.6	31.6
1761	35.1	34.8	34.9	34.9
1781	35.1	34.6	34.7	34.7
1801	37.2	36.5	36.6	36.6
1821	42.1	40.1	40.3	40.3
1841	43.9	40.9	41.0	41.0
1861	45.5	42.1	42.2	42.2
1871	45.7	42.4	42.5	42.5

Selecting GRR to compare the course of fertility according to the four models reveals differences of less than 15% within twenty-five years (less than 5% after a half century). Even differences in estimates of the net reproduction ratio reduce to a matter of a few points within a half century of the start of the inverse projection. Finally, to observe the evolution of a portion of the English population pyramid, select an age group by pressing *A <SPACEBAR>*, typing a group (e.g., 0, 0-14, 15-49, or whatever), and tapping *<ENTER>*. This display and all age-dependent statistics from this experiment support Lee's argument about the robustness of the inverse method, and thus greatly simplifies population

projections for the past. With good data and a long series of fifty or more years, informed, perhaps even arbitrary assumptions generate reasonable results.

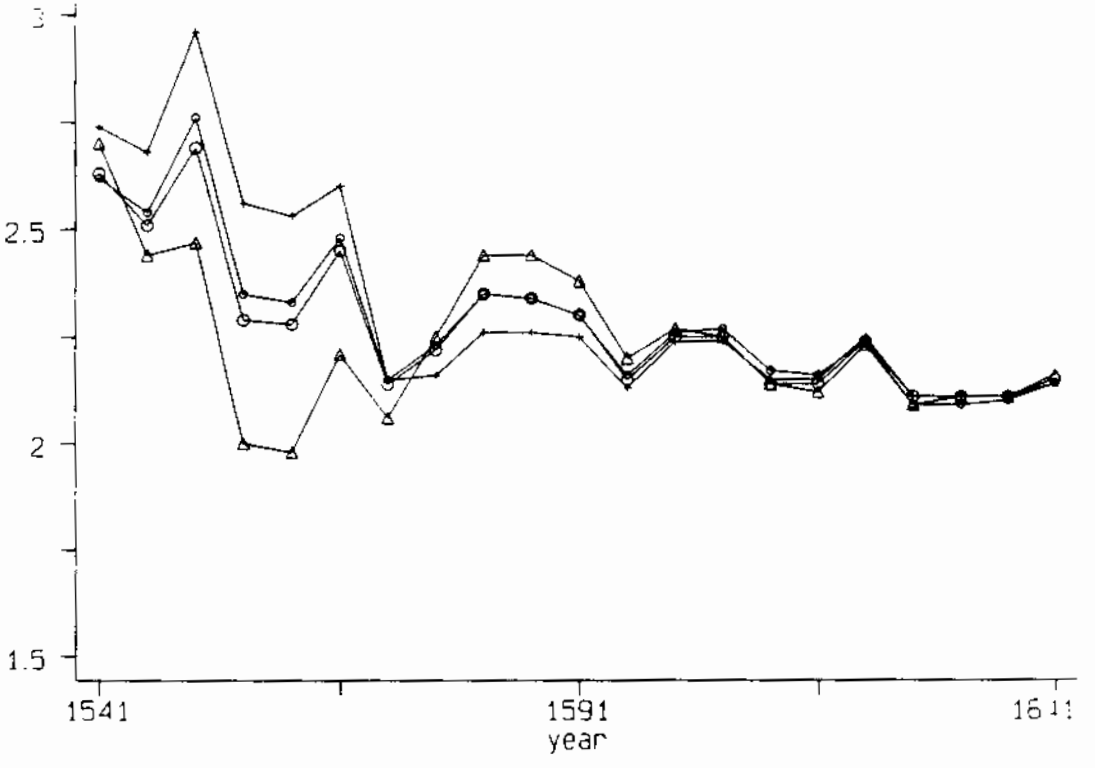
When inverse fails

Wachter sounds a note of caution, noting particular conditions under which ergodicity, and inverse projection, can fail (pp. 286-7). The key is "K", the index of mortality variability. When K deviates greatly from 1, distinct demographic states are called for. The If Age procedure (chapter 3) provides a solution, adjusting mortality, fertility, and even age structures for any period.

Graphics views

On a graphics system *POPULATE* quickly plots any of its demographic statistics to the screen. On text systems, *View List* is available to compare the numerical results from many models, one statistic at a time. To view the big picture, reset zoom to 1541-1871 (*<ESC>Z<ENTER> 1871 <ENTER> <ENTER>*). The graphics user should toggle Graphics on, by pressing *G* at the main menu, *Wipe* the screen, select a single age-dependent statistic (e.g.,*Statistics Grr*; toggle *Population*, *Birth*, *Death* and *Life* off, and press *<SPACEBAR>*), and then *View* models *AFGI* in rapid succession. (To accomplish a similar effect on text systems, press *VLAFGI<SPACEBAR>G*, to list the gross reproduction ratios for models a, f, g, and i.) The screen will display a visual image of the very slight importance of the age assumption on fertility estimates and further confirm the power of Lee's inverse method (Figure 9).

Figure 9. The Diminishing Effect of Initial States: Gross Reproduction Ratio under Four Assumptions



To view changes in age structure, Wipe the screen, return to the statistics menu (*<SPACEBAR>S*), toggle *Grr* off and *Sumage* on, then *<SPACEBAR> View A*. This displays the cumulative age distribution of England's population over more than three centuries. Note the extraordinary volatility of past populations.

For a graphic demonstration of how quickly vital rates overwhelm initial states press *FGI*. (On non-graphics systems, use *View List AFGI Age <ENTER> 0-14 <ENTER>*, for a similar effect.) This is not to say that age structure settings are trivial or unimportant, but that in the long run vital rates are the most powerful determinants, as these figures show.

When age is important

The importance of changing vital rates on age structures can be appreciated by reviewing results from experiment 1. Wipe the screen and press *BCDE* to examine the effects of a European demographic revolution on age structures. *C* reveals the age structure that would have emerged under constant mortality and fertility rates; *D* weighs the effects of changing mortality, and *E* shows what would have happened if fertility alone had changed and mortality stayed constant. Whether these results are viewed as graphs or tables, they allow one to easily discern the comparative effects of mortality and fertility on the English age structure. Note that fertility, not mortality, change had--and as a matter of principle, always has--the most dramatic impact.

Conclusion

These experiments illustrate the power of Lee's inverse method[7] and the range of features available with *POPULATE*. Commands, menus, and additional features are explained in chapters three and four, and data preparation, in chapter five.

[7] Alain Blum and Noël Bonneuil argue that both methods rest on the same principles or constraints and thus one should not be surprised that they produce similar results; see "Projections rétrospectives des populations du passé", in VIII Colloque National de Démographie, *Les Projections Démographiques Actes du colloque* (Paris: Presses Universitaires de France, 1987), I:58-9.

III. Composing Models: If. . .

There are three types of commands:

1. to specify models (If commands)
2. to change the display
3. to perform various housekeeping functions (filing - tutorials).

Impulse modeling

The possibility of adjusting births, deaths, migration, etc. for any quinquennium without exiting from the program allows for a great deal of flexibility in modeling. Alternative data series may be prepared before running *POPULATE*, then activated inside the program to generate additional models. This strategy was used to examine the English demographic revolution above. The program also facilitates impulse modeling, editing any data on the fly, without using an external editor, complicated instructions, or modifications of the source code. The If command is the key.

If
If: Age Constant Lifetable Variable Quit Help

If

To activate or edit assumptions or data for a subsequent projection press *I* at the main menu. Any combination of assumption types--*A*ge, *C*onstant, *L*ifetable, or *V*ariable--is permitted in a single model. Selecting *If A*ge displays a quinquennial layout on the screen to allow any of the age variables (fertility, mortality, migration or population age structure) to be activated in any quinquennium. *C*onstant applies a constant adjustment factor to all quinquennia. *L*ifetable permits the selection of a mortality and age structure from any of 192 model lifetables contained in the file "*POPULATE.LIF*" (96 unisex and 96 female tables). *V*ariable adjust values of any variable for specific periods or quinquennia.

If
Age

If Age

This option permits one to switch any age structures (mortality,[8] fertility, migration, or population) at any period in a projection. Thus, if say the mean age of childbearing is assumed to have shifted halfway through the projection period, this hypothesis can be incorporated into a model, by pressing *If A*ge (position the cursor at the desired quinquennium using the arrow keys) and selecting the corresponding hotkey from the menu of age structures. Figure 10 shows the initial assumptions for England in 1539 with a shift to a late mean age of maternity (33 years) in 1559, and back to 31 in 1759.

[8] Wrigley and Schofield suggest that a change in the age structure of mortality occurred in England (pp. 455), but apparently their back projection does not easily accommodate variations of this sort. See Appendix 15.

Figure 10. Screen Display for Activating Age Structures for any Quinquennium (England, 1539-1873)

```
                    Point  to quinquennium.  Select age structure
1539          DUCR                                                V
1579
1619
1659
1699
1739                                                              U
1779
1819
1859
  C Lxlee     D Age      R Migrage   S Bear27    U Bear31    V Bear33    X W37
  Y A37r8     Z W57      0 A57r8     I W37       2 A37r20
```

Figure 11 compares the gross reproduction ratio generated by this model with that of the baseline.

Figure 11. Gross Reproduction Ratios From Model A and Model K (Mean Age = 33, 1559; 31, 1759)

The *If Age* feature can be implemented for any quinquennium and any of the age variables either included in the program or read in as data from the input file. To toggle a selection off, position the cursor at the

desired quinquennium and tap the corresponding age variable key. Note that age conditions for the first quinquennium are set solely by the *If Variable* command as discussed below.

If
Constant
If Constant: Births Deaths Migration Population Restore

If Constant

adjustments can be for one or more variables and are applied to each quinquennium. To activate a constant adjustment, press hotkeys: *If Constant {B D M P}* {type data value} *<ENTER>*.

B adjusts Births for under or over registration
1.1 = increases births by 10%
.9 = deflates births by 10%

D adjusts Deaths for under (or over) registration
Death factor<return> (same as births)

M takes into account Migration
1.002 indicates 0.2% in-migration each quinquennium
.98 = 2% outmigration

P sets Population size to start a projection:
Type alternative population total *<ENTER>*

R restores the above settings to their initial values.

If
Constant
Migration
Enter Migration Rate (0.998 = .2% outmigration per period)

For example, to adjust a projection for constant in-migration of 0.1% per quinquennia, press *If Constant Migration* 1.001<return>. This global adjustment will remain in effect for subsequent models, until changed or nullified (by simply pressing return at the "Enter Migration Rate" prompt instead of entering a rate).

If
Lifetable

If Lifetable

This function activates lifetable parameters from any of *POPULATE*'s 192 tables (female or unisex, 4 regions and 24 levels ranging from life expectancy at birth of 20 to 77.5 years; Figure 12).[9] A selected table may be used as the initial mortality assumption for the first quinquennium of a projection or it may be activated in any quinquennium when first selected by *If Lifetable* and then placed in the *If Age* quinquennial array. *Lifetables* also may be selected, activated, viewed or (heaven-forbid!) edited by the *If Variable Lifetable* commands.

[9] Using corrected values for the computation of infant mortality as reported in *Population Index* (Spring 1987), p.4.

Figure 12. Lifetable Selection Screen

Life expectancy at birth in years: Press {ab...01) to choose a model

A 20	B 22.5	C 25	D 27.5	E 30	F 32.5	G 35	I 37.5
J 40	K 42.5	M 45	O 27.5	P 50	R 52.5	S 55	T 57.5
U 60	V 62.5	X 65	Y 67.5	Z 70	0 72.5	1 75	2 77.5

Select a level:
Press {AB ... 01}, else continue

Once the lifetable function has been pressed (*If Lifetable*), select a region (*W*est, *S*outh, *N*orth, *E*ast), then a level from the lifetable menu by pressing the respective hotkey (*A* = 20 years, *I* = 37.5, *T* = 57.5, and *1* = 75.0), and finally enter the desired growth rate for computing the appropriate population age structure. Growth rates are expressed in thousands (no decimal) and may range between +/- 50 (that is, plus or minus five percent per annum). Whenever a mortality pattern and age structure is invoked by *If Lifetable* the specified survival probabilities and age structures are automatically activated for the next model. The selection may be changed from the *If Variable* menu, which automatically appears after selecting any lifetable variables.

If Variable

This is the most flexible adjustment feature in the program. It is used to activate, view, or edit variables in preparation for a projection. Press *If Variable* to display a variable menu listing the names of each of the currently available variables and their respective hotkeys. Active variables are indicated by an exclamation mark, "!" (Figure 13).

Figure 13. If Variable Selection Screen

!A Births	!B Deaths	!C Lxlee	!D Age	!E MigrW+S	F Migrlee	G Tpoplee	I Bcnst
Dcnst	K Bobsrvd	M Dobsrvd	O Brates	P Drates	!R Migrage	S Bear27	T Bear29
!U Bear31	V Bear33						

Model B 2724p
Press {AB ... UV}, else continue. <F1> to view Births

Variable types

When the program is initiated, the first data series of each type (births, deaths, migration, total population, fertility age structure, pairs of survival probabilities, etc.) are automatically activated.

When a selection is made from the *If Variable* or *If Lifetable* menus, the previous selection of the same type becomes dormant and the current one is activated for viewing, editing, or modeling. Thus as many as 48

variables may reside in memory, but only those that are currently toggled on by the appropriate hotkey on the *V*ariable, *L*ifetable, or *A*ge menus can be viewed, edited or used in projecting a model. For modeling purposes, migration and total population variables are considered to be the same type. Migration variables take precedence over population variables in the computation of a model. If both types are active at the moment of projection, the program automatically de-activates the total population variable.

Activating a variable

The first birth and death series read in at the beginning of a run are active throughout a session. Note, however, that, aside from the initial birth and death series, the program permits only one set of adjustments of each type (Population, Age, Migration, etc.) to be active for any specific quinquennium. Any adjustments invoked by a subsequent set of birth or death adjustments are to the corresponding initial series.

Replacing birth or death entries

Values from the initial series of vital events can be replaced entirely by activating an adjustment set which initially contains or is subsequently edited such that specific quinquennia have the equals operand followed by a value. Consider the "births" and "bcnst" data series from the example data file *ENGLAND.POP*. The "births" series contains Wrigley and Schofield's estimates of the number of births per quinquennium from 1541 to 1871. The second series, "bcnst" (births constant), retains the original series through 1761 (multiples the original values by one), then for each subsequent quinquennium from 1761 to 1871 replaces the initial series with a birth rate of 32.3 per thousand.

Births The W+S birth series for England ,541,528,583,508,517,581,536,576,...
*Bcnst observed births to 1761; .0323 to 1871, *1!1761, =.0323, =.0323 ! 1871*

Migration age

"Migrage" refers to the age structure of net migration. The programmed default is that of migrants to Stockholm in 1841, used by Wrigley and Schofield in their work:

0-4	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*50+*
.065	*.045*	*.040*	*.100*	*.200*	*.200*	*.200*	*.075*	*.03*	*.03*	*.015*

This variable may be edited like any others, or an alternate migration age structure variable (name begins with a "G") entered in the data input, or *XXX.POP*, file.

Mean age of maternity

"Bearxx" indicates mean age of childbearing. Four ages, 27, 29, 31, and 33 are included in the program:

age	*15*	*20*	*25*	*30*	*35*	*40*	*45*
27:	*.029*	*.055*	*.054*	*.037*	*.020*	*.004*	*.001*
29:	*.018*	*.042*	*.056*	*.044*	*.028*	*.010*	*.002*
31:	*.008*	*.032*	*.054*	*.050*	*.034*	*.018*	*.004*
33:	*.002*	*.019*	*.047*	*.056*	*.046*	*.025*	*.005*

Once again additional parameters may be entered in the *XXX.POP* file (variable name begins with "Fnn", where nn = mean age). The values are weights used in distributing births by the ages of mothers. When this variable is included in a file, its values must sum to .2 (one-fifth of quinquennial births to compute single year fertility estimates).

Edit or View a variable

To view or edit a variable, toggle its hotkey, then press function key 1, *<F1>*. The variable name and description will appear at the top of the screen along with a table of its values and operands at five year intervals.

To edit values of a specific quinquennium, use the arrow keys to move the cursor to the desired year, tap the appropriate operand key (*-+=), type a value, and press <*ENTER*> (Figure 14). When the entered value is greater than 1, the cursor will automatically advance to the next quinquennium. If less than one, confirm the edit by pressing any arrow key or <*ENTER*>. While the editor is active, pressing <*ENTER*> causes data to be accepted, and the cursor to advance. To exit the editor, press <*SPACEBAR*> or <*ESC*>.

Figure 14. Point and Press Editor

Births estimated by Wrigley and Schofield

1539 =541	=528	=583	=508	=517	=581	=536	=576
1579 =617	=623	=635	=625	=690	=727	=713	=717
1619 =766	=745	=777	=800	=825	=794	=700	=763
1659 =688	=761	=738	=744	=742	=799	=779	=783
1699 =836	=809	=753	=846	=883	=895	=895	=967
1739 =916	=943	=974	=983	=1041	=1075	=1156	=1222
1779 =1253	=1369	=1512	=1588	=1633	=1877	=1951	=2232
1819 =2341	=2414	=2368	=2509	=2687	=2782	=2994	=3189
1859 =3427	=3675	=3865					

Position cursor (press arrow keys). Edit (press *+=-). <space> to continue.

Operands and values

When the editor is selected, the values of the current variable are displayed and standard keyboard arrow keys are used to move the cursor around the screen. Pressing an operand (+-*= to add, subtract, multiply or set equal to, respectively), the insert key, or any number invokes a request for a value for the current period. The operand determines whether a value will replace an element (=) or whether an adjustment will be absolute (+-) or proportional (*). Thus entering *1.1 increases the value of the variable for the specified quinquennium by 10%, while +1000 would increase the value by one thousand.

Operand	Action	Example	Meaning
*	multiply	*.9	decrease 10%
+	add	+1000	increase 1000
-	subtract	-1000	decrease 1000
=	replace	=1000	equal 1000

Edited variables appear on the variable menu with a "■" to indicate that values have been changed. Once used in a projection, the edited values are written to the results file and the "■" disappears.

Interpolation

When birth, death or migration variables have zero values, they are automatically replaced with logarithmic interpolations, provided that the bracketing known values have identical operands. Thus, "=.035,0,0,0,0,=.030" becomes "=.035, =.034, =.033, =.032, =.031, =.030"; but, "=.035,0,0,*1.05" is interpreted as "=.035, =.035, =.035,

"1.05" because of the different operands. Mix operands to avoid interpolation (see "bcnst" example in experiment 1).

Sequencing adjustments

Interpolations, if any, are computed first, then quinquennial, and finally constant adjustments are made. Thus, a variable adjustment of 10% compounded by a constant adjustment of 10% for a specific quinquennium produces a total adjustment of 21%.

Undesirable results

When a projection produces unexpected results, first check the constant adjustment factors which define the model (see title of model on line 2). If those are sensible, the problem probably lies with one or more of the period variables. To check this possibility, view the offending statistic in tables mode and identify the quinquennium in which the surprise appears. Then turn to the editor (*If Variable {TOGGLE HOTKEY OF SUSPECT VARIABLE} <F1>*) to confirm that individual adjustment factors are as expected. For example, if one intended to set a birth rate at, say, 30 per thousand for a particular period, but actually typed "=030", the program would interpret this to mean "30" births (in hundreds, thousands, or whatever), rather than the desired rate ("=.030").

Resist the temptation to blame unexpected results on programming bugs. When surprises occur, blow off steam. Curse the programmer. But before discarding the program or telephoning for help, carefully check the values of all active variables.

4. Screen Display and Printing

The following commands have no effect on how projections are computed, but instead determine the type and manner of statistical results to be displayed or printed. When the screen becomes messy, Wipe it clean, then quickly re-display the desired statistics for specific projections. The 15 display commands will be examined in order of importance.

Axis Chart Configure File Graphics Learn Models Note Print screen Restore Statistics Tables View Wipe Zoom

Statistics

This command may be activated at the *POPULATE*, If and Options menus, by pressing *S*, to select Statistics to be displayed. Active statistics are indicated by "!":

Statistics: !Pop !Birth !Death .Migr !Grr .Nrr .K !Life .0q .Cwr .Age .Sumage

Statistics are computed for the mid-point of each five year period; see below for formulas.

P = mid-point population
B = crude birth rate
D = crude death rate
M = net migration rate
G = gross reproduction ratio
N = net reproduction ratio
K = normalized death rate
L = life expectancy at birth
0 = probability of dying during the first year of life
C = child-woman ratio (0-4/15-49)
A = age groups (0,5,10+,15-44,30-54,50,25, etc.)
S = sumage (cumulative percentage distribution, ages 0-4, 0-9, etc.)

Options
Models

Models

To review names and adjustments associated with each projection press Options Models. When computer memory is exhausted projections are wrapped around to recycle memory allocated for the first projection. For example, with the English population dataset, the maximum number of projections which can be stored in memory is twelve. Thus, the thirteenth projection replaces the first and so on. This action only affects the display. Unless the file option is off, a copy of all statistics and adjustments is automatically filed to disc as each projection is made.

View

To View results from current models (identified by letter), press View and letter of desired projection.

View
Press {AB...} L=List 1 stat/many models, else

View, List

Currently selected statistics are displayed (graphics or tables) with zoom settings. Several models may be displayed one statistic at a time, by first pressing *"L"*, then selecting the desired models (!). Once the selection of models to be displayed is completed, press <*SPACEBAR*> to access the statistics menu and select the desired statistic. When finished, press <*SPACEBAR*>.

Zoom

Zoom contracts or expands the number of quinquennia to be displayed and the interval between displayed statistics (5, 10...25 years), within the bounds set by the year instruction at the beginning of the run.

Zoom
Enter first year to graph xxxx-yyyy (or 1-t) <enter>
Enter last year to graph xxxx-yyyy (or 1-t) <enter>
Enter interval between periods (5, 10...25) <enter>

Horizontal scale

The horizontal scale depicts years from beginning to end (according to the current zoom setting, if any). The end year is automatically determined from the birth and death series, but both the beginning and end years may be changed by Zoom. Actual projections are not affected by Zoom settings.

Axis

This command is only important for graphics, and in the rare instance when an axis must be extended (life expectancy goes beyond 100 years!) or contracted (life expectancy never exceeds say, 50 years). Vertical axes or scales are tricky because of the need to portray on a single screen, say, population in units of millions, life expectancy in years, rates in thousands, ages in percents, etc. Automatic scales have been designed to facilitate a ready interpretation of each graphic. Moreover, to provide an exact indication of scale, the initial and most extreme values for each statistic are labeled on the screen along with its graphic.

Default Axes

The vertical axis of each statistic is set according to the following limits:

Population, 0 to 1.2*(Initial Population + Total Births - Total Deaths + Total Migration)

Annual crude birth rate, 0-99

Annual crude death rate, 0-99

Net migration rate per annum, .995 (0.5% out-migration per annum) - 1.005 (0.5% in-migration)

Gross and Net Reproduction ratio, 0 - 4

K, an index of mortality variation, +/- 10

Life Expectancy, 0-99 years

Child woman ratio, 0-1400

Ages, 0-25%; grouped ages, say 15-49, 0-100%

Sumages (cumulative age distribution), 0-100%.

Axis commands

When adjustments substantially inflate the rate of population growth, *POPULATE* automatically computes a new scale adequate for viewing all population projections (and wipes the screen so that all graphics are displayed with the appropriate scales).

The axis command is available for adjusting vertical scales. To activate the command, press Options Axis. Select a statistic from the menu, then enter a scale adjustment factor. Factors greater than 1

extend the range (e.g. "2" for life expectancy would extend the range from 0-100 to 0-200 years); values less than one contracts (.5 for life expectancy, reduces the range to 0-50 years). The vertical axis may be changed for any of the statistics, except cumulative age distribution (which always sums to 100%).

Configure

This option permits a rapid reconfiguration of the software for screen or printer displays. Use this option to change the adapter type (handy for Hercules systems to print text displays--*<ESC> O*ptions *C*onfigure *A*dapter *M*dpa *V*iew *AB*...*<CTRL> <SHIFT> <PRINT SCREEN>*; to regain Hercules configuration press *<ESC> OCAR*) or to switch between color and monochrome displays--Options Configure Monochrome. Configuration changes are filed to disc when a session ends.

Options Record

Record

The recorder may be activated from the Options menu by pressing *R*, or at any time, by tapping *!*. Recording stops when *!* or *R* is toggled off. The process may be interrupted by pressing \, and resumed by toggling \ again. When a recording begins, a title is requested for the lesson. Then at each keystroke, there is an opportunity to type an additional one-line prompt which will appear as the lesson is played back. When the recorder is on, always press <spacebar> to move between menus or <esc> to jump directly to the main menu.

.LRN files

Lessons are stored in the current file (*XXX.LRN*). Thus when *ENGLAND.POP* is the active data file, the tutorials in *ENGLAND.LRN* is automatically accessed. Lesson files may be edited by any word processor which produces standard end of paragraph codes. When the target is a relatively knowledgeable person, it may be desirable to simplify lessons. Access the *XXX.LRN* file with a standard word processor. Replace several specific prompts from the same menu, by a single generic prompt beginning with a space <spacebar> or an escape <esc> and including all the commands which should be activated from a single menu. Thus, to activate models a e f g, these four commands (four paragraphs in the .lrn file), could be replaced by one generic command: "<space>select models a e f g then press space".

Note that there is only one learn file per *.POP* file. Use operating system *RENAME* or *COPY* commands to manage more than one *.LRN* file per dataset.

Learn

Tap *L* (Learn) at the Main or Options menu to start a tutorial, a series of pre-recorded key strokes and prompts to guide the learner through one or more lessons. The student selects a lesson from a menu of options in the learn file, then taps *<SPACEBAR>* to begin (or *<ESC>* to skip) the tutorial. While a lesson is engaged, the command lines are expanded to provide additional prompting. Although the program insists that any recorded keystrokes be tapped in sequence, it also allows the student freedom to experiment (or to fail, but only the student knows)! If the lesson becomes fouled, press *<BACKSPACE>* to step backward through the lesson, or *<TAB>* to skip forward. To stop a lesson, press *L*

at the *POPULATE* or Options menu, or press <*ESC*><*ESC*><*ESC*>, rapidly in succession.

Chart

Chart prints rough-and-ready screen graphics to paper with a dot matrix printer (not available on *HERCULES* systems). Before running *POPULATE*, turn the printer on and run the operating system program "*GRAPHICS*". If the system response is "Bad command or file name" (or your system is not 100% IBM-PC compatible), *POPULATE* will not chart graphs to paper.

At the main menu, first select statistics, then press Chart to pop open a menu to select *V*iews and type a *T*itle, then press <*SPACEBAR*> when what you see on the screen is what you want on paper.

Chart

The chart is composed on the screen in two stages. First view models, and then enter a title. Activating Chart will cause the screen to change color and switch to double-width mode in preparation for plotting the screen display. Now compose the graphic by tapping the hotkeys of desired models. By pressing <spacebar> or any key which is not a model, a title prompt will appear. If no change in title is desired, press <*ENTER*> else type a string of up to 39 characters and then press <*ENTER*>. To escape, type <*ESC*>, then press <*ENTER*>. Otherwise, if the system is fully IBM-PC compatible (from operating system BIOS to dot matrix printer and graphics interface), a screen-sized chart of the currently displayed statistics and models will be printed.

Note that characters are printed double-width in graphics mode. Once printing is completed (this may take a while), control will return to the main menu. At that time the printer may be turned off, the paper advanced, etc.

5. Data and Data Files

Data types

Conventional projections are made from hypothesized demographic events--births, deaths, and migration--all classified by age. *POPULATE* assumes that only crude data are available, and that model age patterns can be used to overcome the lack of detailed age information. Specifically, the program uses the following types of data to construct a demographic balance sheet at five year intervals (code used for each variable type is in **bold**):

1. **T**otal population size at the start
2. Total **b**irths (or crude rates) by quinquennium
3. Total **d**eaths (or crude rates)
4. Net **m**igration (estimates, counts, or rates)
5. **F**ertility age structure (4 models in Populate)
6. Mi**g**ration age structure (1 model available)
7. Mortality **q**uotients or survival **p**robabilities (192 models)
8. Population **a**ge structure (192 models times 100 at .1 intervals)

Only the first three data types are required in a *.POP* file. Nevertheless, whatever age data (real or hypothetical) are available for one or more periods can be used in *POPULATE*'s projections.

Data files

Data must be placed in files on a floppy disc or fixed disc subdirectory along with the program. Data input files should be prepared with a word-processor and saved without special formatting or printing features (ASCII characters only).

```
Enter DATA file name <return> (<return> = {England.pop})
```

Results file

Before projections begin, an input data file name is requested. Then, *POPULATE* requests an output, or results, file name. If no name is given, default name is taken from the input file name, so that xxx.*POP* becomes xxx.*OUT* for results. Results of each projection are filed in Basic comma-delimited format suitable for subsequent analysis by *LOTUS 1-2-3*, *SPSSPC*$^{+}$, *MS-CHART*, *STATA*, etc.

```
Enter results file name (<return> = {England.out})
```

If the results file already exists, there is an opportunity to save it, by typing an alternate name.

```
Results file {England.out} exists. Delete? else.
```

Pressing *D* or *<ENTER>* deletes the prompted file, allowing the entry to be over-written by projections from the current session. Pressing any other key causes a request for a different file name.

Data Preparation

The program checks for seven lines of data:

1. title--must be line one.
2. year instruction (see below)--must be line two.
3. a birth series (rates or counts; there may be more than one set)
4. a death series (same as births)

5-6. 2 lines of survival variables (sets of probabilities from two life tables with similar mortality structures)

7. population age structure

A note appears on the screen when one or more of these variables are not found in the data file. In fact only four lines are actually needed: a title, the year instruction, and birth and death variables. The remaining sets of parameters may be selected within the program from model lifetables, fertility schedules, and the like.

Data example

The data input file should contain instructions according to the following comma-delimited format (spacing and number of digits do not matter; only commas and <*ENTER*>). Each instruction consists of an identifier and its contents. The identifier may be a word or phrase, but must begin with a single letter key code (ybdmpqafg). The word becomes the variable name, and the phrase may contain any additional explanatory information (up to 70 characters); the identifier is terminated by a comma or end-of-line/paragraph mark ("¶" in the examples below; created in conventional word processors by pressing <*ENTER*>).

Identifier, Contents (each item separated by commas)

Example (in italics from the file ENGLAND.POP)

1. "Any title" (must be the first line)

   England Wrigley & Schofield's data + Lee's pxes

2. Year,
   - a. T1 (begin year),
   - b. Tm (end year),
   - c. Sex (F = Female data; else any other value = unisex)
   - d. Initial Population size (use same units as counts of births, deaths, migration, etc.),
   - e. Mean Age at Childbearing (27, 29, 31, or 33),
   - f. number of age groups (>10<18).

   example: *year,1539,1873,U,2724,31,11*

3. Px, Survival Probabilities (may be qxes) 0, 1, 5...n, T>n/Tn

   pxlee survival probabilities used in 1985 Pop Studies article¶
   .745,.855,.950,.962,.951,.941, .935,.928,.919,.908,.893, .74324

4. Px, Adjacent Px (or qx) 0, 1, 5...n, T>n/Tn

   pxadj also from Lee from an adjacent life table¶
   .786,.883,.959,.968,.959,.950,.945,.939,.932,.922,.908, .75065

5. Age, Population Age Structure, 0-4, 5-9, ...n+

   agews age structure for England in 1541 estimated by Wrigley and Schofield,.13,.11,.10,.09,.09,.08,.07,.07,.06,.04999,.15001

6. Births, Number of Births at T1, T5,...Tm. (Erratic spacing produces desired results).
   Births estimated by Wrigley and Schofield , 541, 528 ¶
   583,508,517,581,536,576 ¶
   617,623,635,625,690,727,713,717,766,745.777,800,825,794¶
   700,763,688,761,738,744 ,742 ¶
   799,779,783,836,809,753,846,883,895,895,967,916,943¶
   974,983,1041,1075,1156,1222,1253,1369,1512,1588,1633,1877¶
   1951,2232,2341,2414,2368,2509,2687,2782,2994,3189, 3427¶
   3675,3865 ¶
   The following example, when active, causes the original birth series to be multiplied by 1 from 1539 to 1761, then in 1766, replaces the original series by an annual rate of 32.3 per thousand, which continues through 1871. Operands are discussed in the editing chapter (above); the "!" convention below in special data features:
   Bcnst projects average birth rate for 1661-1761 forward to 1871¶
   **1!1761, =.0323, =.0323 ! 1871*
7. Deaths, No. of Deaths at T1, T5,...Tm. Note the end of line marker ¶ (but no comma) after "Deaths", "523", etc. below. Use one delimiter (either "¶" or ",") but not both to separate data items.
   Deaths Wrigley and Schofield's estimates ¶
   407, 445, 391, 525, 490, 387, 399, 383, 392, 474, 523¶
   500, 505, 485, 576, 586, 551, 663, 589, 670, 728, 632¶
   644, 757, 676, 786, 739, 673, 873, 764, 706, 719, 669¶
   711, 712, 694, 840, 860, 920, 756, 880, 760, 755, 776¶
   882, 881, 889, 858,1015, 985,1014,1092,1173,1144,1263¶
   1359,1385,1451,1461,1573,1665,1828,1907,1989,2071,2289¶
   2356¶
   Dcnst projects 1661-1761 average to 1871¶
   **1!1761, =.0274, =.0274!1871*

Note that data items may be prepared in columns or scattered freely, but in any case, each item must be separated by a single delimiter (either a comma or end of line or paragraph mark).

Data limits

A total of 40 variables may be included in a data input file (alternative birth/death series/rates, birth or death adjustment factors, migration rates, fertility or migration age structures, etc.). When additional lines or variables are present in the file, the program automatically classifies the data by type for use whenever activated by *If Variable* or *If Age* (see above).

Data typing

Each instruction begins with an identifier or variable name (*BDMGTPFA*, for *B*irths, *D*eaths, *M*igration, mi*G*ration age structure, *T*otal population, survival *P*robabilities, *F*ertility age structure, and population *A*ge structure, respectively) which is used by the program to classify variables.

Optional data types

In addition to the types discussed above, the program recognizes and uses the following optional types of data: fertility age structure (*F*), migration age structure (*G*), migration (*M*), and total population (*T*).

Fertility age structures

These should be for ages 15-19...45-49, and the values should sum to 0.200. They indicate weights to be assigned to age groups in distributing births to women of age 15, 20,...45-49. Example:
F31 mean age of maternity = 31 ¶
.008,.032,.054,.05,.034,.018,.004

Migration age structure

Migration age structures are recorded for ages 0-4,...maximum age group and should sum to 1.00. Example:
Gstockholm age structure of net migrants to Stockholm in 1841¶
.065,.045,.040,.100,.200,.200,.200,.075,.03, .03,.015

Migration estimates

Migration indicates estimates of net migration and may be reported as rates (*1.001 = 0.1% net in-migration of total population in a single quinquennium) or absolutes (same units as total population above). Examples:
MigrW+S Wrigley and Schofield's estimates of net migration for England¶
-18,-20,-22,-19,-17,-18,-21,-23,-26, -31, -35, -36, -36¶
-34, -30, -25, -22, -24, -24, -31, -40, -49, -58, -63, -62, -55¶
-45, -35, -26, -19, -18, -20, -22, -25, -27, -28, -28, -28, -26, -24¶
-25, -26, -28, -31, -35, -35, -31, -26, -22, -17, -15, -18, -23¶
-28, -34, -41, -50, -63, -78, -90, -102, -115, -124, -122, -109¶
-102, -117
MigrLee Lee's long swings in English out-migration¶
**.9985,*.9985!1689,*.99915,*.99915!1799,*.9998,*.9986!1859*¶
**.999!1871*

Total population

The total population variable sets a population target to be realized at the beginning of the corresponding quinquennium. Differences between the target and computed population size are automatically attributed to migration, and migration rates computed accordingly. In reporting estimated migration results based on total population, a migration estimate is given only for quinquennium in which there is a population estimate, but the rate applies to the entire set of periods bracketed by estimates. See special conventions below. Example:
TpopLee population estimates brought together by Lee in 1985, 2724!1539¶
4800!1694,8400!1799,21000!1871

Lifetable

This data type activates mortality and/or age structures from the model life tables at the beginning of a session. The Lifetable instruction has five elements: region, level, growth rate, year to activate mortality structure, year to activate age structure. If the year instruction specifies female, then female lifetables and age structures will be retrieved.

Region: west, north, south, east
Level: life expectancy at birth of 20-75 years
growth rate: -50 to +50 per thousand population
mortality year: any year (if greater than maximum or less than minimum, then this is placed in variable list, but not activated)
age year: same as for mortality
Example: *Life,west,37.5,8,1541,1541* - activates both mortality and population age structures for a west population with a life expectancy at birth of 37.5 years and an annual growth rate of 8 per thousand.

Special data conventions.

Total population, migration, births and deaths absolutes should be reported in the same units (hundreds, thousands, ones, etc.). If birth or

deaths are less than 1.0 but greater than zero, they are interpreted as crude rates rather than totals and projections computed accordingly. Rates and absolute values may be inter-mixed. If population age structure values are less than one (e.g., .123), they are interpreted as percentages and should sum to 1.0. Zero values for migration, births, or deaths are replaced, whenever they are active, with logarithmic interpolations between known points. Zero total population provides an alternative treatment. No interpolation occurs. Instead the approximate rate of net migration is estimated to achieve a specified population size for intervals between estimates. For an example, project *ENGLAND.POP* with all migration variables off and "Tpoplee" active. The rates computed for 1694, 1799 and 1871 would apply to the intervals 1541-1694, 1695-1800, and 1801-1873.

!data

To reduce excessive null values from data input, the "!" convention is used to assign values to a particular quinquennium. The "bcnst" variable, used to specify the constant birth rate for model f, multiplies the observed birth counts by one from 1541 through the 1761 quinquennium, then sets the birth rate to 32.3 per thousand through the 1871 quinquennium. Once this or any other type of data has been read in, the editor can be used (*If Variable* {select variable} *<F1>*) to fine tune any variable, estimate, count, supposition, or hypothesis. To project into the future, set a rate for the last observed quinquennium, then a target rate for the last desired period.

End

When encountered in a *.POP* file, the "End" instruction completes the data reading routine. Instructions beyond the end statement are not read.

Mexico, 1500-2000

The following data suggest the program's flexibility in reading data and computing models as well as projecting into the future. To *POPULATE* Mexico, start the program and request *MEXICO* as the data file. Project model a to see, according to one scenario, the evolution of five centuries of Mexican population. Upon displaying the cumulative age distribution for the entire set (press *S*tatistic *S*umage *V*iew), you will observe that the demographic holocaust of conquest remained only a faint echo on the population age structure of the late seventeenth century. Even under the most extreme circumstances, vital rates prove to be more important than initial states. Example (*MEXICO.POP*):

```
Mexico: Pre-conquest to 2000
year,1500,   1998, U,   20000 million in 1500, 27 (early mean age at
     maternity),   11
age Mexico age structure from 1920, 0.14 (% 0-4 yrs),.13,0.12, 0.11, 0.09¶
     0.08, 0.07, 0.06, 0.05, 0.04,*0.11
px model west life expectancy of 27.5 years¶
     .70349,.84166,.95741,.96464,.95386,.94663,.94336,.94044¶
     .9376,.93416,.92153,.74324
px model west 30 years¶
     .72469,.85765,.96163,.96795,.9581,.95145,.94842,.94567¶
     .94284,.93932,.92729,.75065
tpop accepted total population for Mexico at various dates¶
     *1.!1500,=24000!1520,*1,*1!1605,=1000,*1,*1.!1805¶
     =6600!1810,*1,*1!1845,=7700,*1,*1!1895,=13600,*1¶
     *1!1925,16600,*1,*1!1965,50700,*1,69400,*1
```

MIGR a plausible scenario of long swings in Mexican net migration¶
** 1.001!1610 ,*.999!1805 ,*.995!1910 ,* .99 ,* .99 ,* .99 ,* 1 ,* 1 ¶*
** .99 ,* .99 ,* .99 ,* .99 ,* .99 ,* .985!1997 revenge for the war of '48!*
BIRTHS long estimates (-1920) counts (1920-1980) and projections, .048
,.048!1545,.036,.036!1600,.048!1625,.048!1805 ,.045!1820¶
.045!1900,.048!1915,3300 ,3500 ,3800 , 4127 , 4616 , 5288, 6156¶
7328 , .049 , .045!1970, .02!1997 birth control and hardship...
DEATHS Cook and Borah's holocaust scenario recovery 20th century drop¶
.038 , .038!1515 ¶
.1 catastrophe every decade throughout the 16th century, .1!1585¶
.05 ,,.05 ,.042 , .038 , .038 ,.038!1805,.042 independence mortality ,¶
.038,.038!1875 , .034!1905 , .042 , .042 , 2070 , 2113 , 2303 ¶
2230 , 2299 , 2118 , 2110 , 1992 , .013 , .006!1997

Checking data

Before any computations begin, data are always checked for consistency as they are read into memory. If unexpected patterns are found, a message is displayed at the bottom of the screen. Once this step is complete and before the first projection begins, a menu is displayed to permit editing of any variable, activating a lifetable (see *If Variables* above), or setting any of the age parameters (*If Age*). After adjustments are complete or a desired set of variables activated, if any, press *<SPACEBAR>* to initiate the projection. Whenever the file *ENGLAND.POP* is requested from the start-up menu, the first model is computed directly without further ado.

For additional information and complete specifications, see the *File* and *Data* help screens or examples in *ENGLAND.POP* and *MEXICO.POP*.

Female only projections

When "F" is specified on the year instruction, Populate shits into female only mode. All input data--population size, births and deaths (counts or rates), migration, etc.--must refer to females. When lifetable parameters are requested by If Lifetable, female values will be retrieved. Similarly, statistical results, including the reproduction ratios, refer to the female population. Normally, *POPULATE* assumes equal sex ratios at all ages. When this is not the case--due to differential mortality or migration--more reliable results will be generated by working with estimates for the female population.

Results

Results written to the output file consist of two information lines, demographic statistics for each period, and specifications for each projection:

Information: Title. Date, Time

Projection: Settings for Initial Population and adjustment factors, if any. Whenever a variable is edited then used in a projection, all its values are written to the results file in *POPULATE*'s comma-delimited format. Names of active variables are also positioned in the results file, immediately preceding the title of the model.

Statistics are written to the results file, one line for each quinquennium (comma delimited), as follows: Year, Beginning and Mid-quinquennium population, Crude Birth, Death, and Net Migration rates, GRR, NRR, K, Life expectancy, infant mortality, % pop aged 0-4, 5-9, ..., age n

6. Miscellaneous

Source Code

Portions of the source code of *POPULATE* are available for inspection, but the strengths and weaknesses of the program come through testing. It does seem to perform adequately on the English data and a number of datasets from other regions.

Zbasic

Written in *ZBASIC*[10], a many featured variant of compiled Basic which runs on MS-DOS and Macintosh systems, *POPULATE* is a bit too complex and compact (59k of tightly packed source code) to permit tinkering by the uninitiated. All variates, variables, and vectors are common to the main program and all subroutines. Data are placed in a single mammoth vector managed by pointers, classifiers, labelers and the like. Statistical results also are computed into a single one dimensional array to exploit every byte of available memory. Menus, commands, and messages are packed into a garbage-pit-like character vector with a single beginning and end controlled by another vector filled with pointers. In the interest of speed and flexibility, there are no multi-dimensional arrays in the program. Nevertheless, or rather consequently, should there be a demand, when new operating systems become available, many of the present limits could be lifted by simply changing settings in DATA statements at the beginning of the program.

Thanks to:

Renee Holoien (Project Woksape) provided facilities and encouragement.

Ron Lee developed the inverse projection method and suggested improvements to *POPULATE*.

Robert Rowland offered helpful programming hints in his program, *MIGSMAM*, which computes singulate mean age at marriage adjusted for mortality.

Robert Jackson tested *POPULATE* with trying data from a large number of eighteenth and nineteenth century California missions.

George Alter suggested improvements for the variable, lifetable and tutorial screens.

Steven Ruggles relentlessly searched out errors and annoyances.

CELADE-Costa Rica provided survival probabilities from their *PANDEM* program (get it!).

And Steven McCaa, after Oedipean assaults on the program, made valuable suggestions about design and flow.

Bugs and slugs

We hope that the tenacious user will find that errors from *POPULATE*'s computational short-cuts are considerably less than those inherent in the data or from the crudeness of assumptions. In any case, Ron Lee, the developer of inverse projection techniques, has not endorsed this program nor is he responsible for its shortcomings. The authors are solely responsible for inaccuracies, computational errors, bugs, slugs, or whatever.

[10] *Zbasic* is a trademark of Zedcor Inc. (4500 East Speedway Blvd., Suite 22, Tucson, Arizona) for its interactive Basic compiler.

Problems with Populate?

Please send a note relating as much detail as possible (screen prints of all active variables and unexpected results, etc.) to

Robert McCaa, Department of History,
University of Minnesota, Social Sciences 614,
Minneapolis, MN 55455 USA BITNET: rmccaa@uminn1

Methodological or applications questions should be directed to:

Prof. Héctor Perez-Brignoli
Apdo. 377
2050 San Pedro, Costa Rica

Shareware

If *POPULATE* is worth something to you, please send a contribution payable to Robert McCaa at the address below (suggested: $25 for individuals; $50 for a site license with duplication privileges; for Latin America, *se acepta canje*).

Proceeds are contributed to the *Latin American Population History Newsletter*. We gratefully appreciate international postal coupons, postage stamps, winning lottery tickets or cash (small denominations, please) as well as offprints of relevant publications.

Obtaining a copy of Populate

Specify 3 1/2 or 5 1/4 disc; send request and contribution to:
POPULATE, Social History Research Laboratory
Department of History, Social Sciences 614
University of Minnesota
Minneapolis, MN 55455 USA

Go forth and POPULATE--cautiously!

The quality of a projection rests on data accuracy and the validity of one's assumptions. There should be no surprise that projections based on complete data and complex algorithms will produce more reliable estimates of fertility, mortality, and age structure. Where demographic knowledge is slight and the data few, *POPULATE* projects a beams of light, if only faintly. Its scope and intensity can be adjusted by experimenting with the assumptions on which projections are based.

Bibliography.

Blum, Alain and Noël Bonneuil. "Projections rétrospectives des populations du passé", in VIII[e] Colloque National de Démographie, *Les Projections Démographiques Actes du colloque* (Paris: Presses Universitaires de France, 1987), I:42-62.

Brunborg, H. "The Inverse Projection Method Applied to Norway, 1735-1974". Unpublished ms.

Lee, Ronald L. "Inverse Projection and Back Projection: Comparative Results and Sensitivity Tests For England", *Population Studies*, 39(1985) 233-248;

"Estimating Series of Vital Rates and Age Structures from Baptisms and Burials: A New Technique with Applications to Pre-industrial England", *Population Studies*, 28(1974) 495-512.

Econometric Studies of Topics in Demographic History (New York: Arno Press, 1978).

Perez Brignoli, Héctor. "Nuevas Perspectivas de la Demografía Histórica en América Latina", *Latin American Population History Newsletter*, 12(Fall 1986) 7-14.

Smith, P. O. and Shui-Meng Nu. "The Components of Population change in Nineteenth Century South-East Asia: Village Data from the Philippines", *Population Studies* 36(1982) 237-256.

Wachter, K. W. "Ergodicity and Inverse Projection", *Population Studies*, 40(1986) 275-287.

Wrigley, E. A. and R. S. Schofield. *The Population History of England, 1541-1871: A Reconstruction*, (Cambridge, Mass: Harvard University Press, 1981).

Enhancements Version 2.2

Correct help screen response to *unexpected* end of data input file.
Ignore rounding errors in data input file (<.01).
Select any desired background color from a palette of 16 colors.
Compute crude birth and death rates from compounded mid-year population (instead of arithmetic average).
Set the infant mortality rate floor at .005 and ceiling at .900.
Escape from any menu to main menu, by pressing <*ESC*>.
Streamline treatment of common commands and keys.
Place lifetable menu on a separate screen.
When editing any variable, display its description along with its name and values.
Highlight tutorial instructions to stand out on the screen.
When in Learn mode, skip backward or forward in a lesson by pressing <*BACKSPACE*> or <*TAB*>; to interrupt a lesson tap <*ESC*> repeatedly.
Place net reproduction rate on the menu of available statistics.
Increase the maximum number of years projected from 500 to 640.
Increase the capacity of the variable menu from 30 to 48.
Allow models to be named; require two strokes to project a model.
Permit the color of any graphed statistic to be reset (instead of wholly automatic).
Print tables to a laser printer (in addition to dot matrix).
Allow the vertical axes of statistics to be collapsed or extended.
Set Zoom automatically such that viewing a table displays a single screen of statistics from first period to last.
Include a greater number of *POPULATE* datasets with program disc.
Add an optional "End" instruction in the data input file, to allow data to be in the input file without being read.
Change interpolation, such that when operands of consecutive non-zero values are unequal, zero values are treated as constants, and are re-set to the preceding value. When operands are identical, geometric interpolations are computed for intermediate values of birth, death, and migration estimates (same as previous version). Adjustments for total population are simply reset without interpolation.
Set configuration parameters (adapter, colors) from a special installation program (*PINSTALL*) without having to run *POPULATE*.
Permit projections without filing results to a disc file (Options File).
Accelerate program initiation (loading of help screens, menus, etc.; ten-times speedier for floppy disc systems).
Replace the "Lx" data type with "Px" or "Qx". "L" is now reserved for Lifetable, to automatically set lifetable variables for any period from within a *POPULATE* data file.
Permit projections for female population as well as both sexes combined; append 96 female lifetables to unisex set.

Formulas (E = summation)

"Normalized" death rate (k)

Where,

L_x = total number of person-years lived between exact age x and x+5 in the stationary population

μ = total number of 5 year age groups

Þ = open ended age group

Q_x = the death rate for age x, L_{x+5}/L_x

Then, $D_x = S^2_x \cdot S^1_x$,
where S^2_x is the survival rate from life table 2
and S^1_x is the survival rate from life table 1 at age x.

And, $k_t = (D_t - E(Q_{tx}*N_{tx}))/(E(D_{tx}*N_{tx}))$, at time t, x = 0 to Þ

Then, $P_{tx} = Q_{tx} + k_t * D_{tx}$
If, $P_{t0} < .1$, $P_{t0} = .1$
If, $P_{t0} > 1.$, $P_{t0} = P_{t-5,0}*.9$
If, $P_{t0} > .995$, $P_{t0} = .995$

And, $N_{t+5,x+5} = N_{tx}*P_{tx}$
$L_{t0} = 500000*P_{t0}$
$L_{tx} = L_{t,x-5}*P_{tx}$, for x = 5 to μ
$L_{tÞ} = (L_{t\mu}*P_{t\mu})/(1-P_{t\mu})$
$e_{t0} = EL_{tx}/100000$, x = 0 to Þ

Gross reproduction ratio

Where, a is the lowest age at childbearing and b, the highest

And, f_x is the normalized age pattern of fertility, for ages x a to b, such that $Ef_x = .2$.

Then, $F_t = E((N_{tx} + N_{t+5,x})*f_x)$, x = a to b
$G_t = (B_t/F_t)*.4$

Net reproduction ratio

Where, M = mean age of childbearing

i = TRUNC(M/5), 5 year age group for mean age at childbearing

c = (M-(i*5)/5

Then, $N_t = G_t*((L_i-(L_i-L_{i+1})*c)/500000)$

Mid-period population, $T_{t+2.5}$, and crude rates

$T_{t+2.5} = EXP(LOG(T_t)+LOG(T_{t+5}))*.5)$
$CBR_t = B_t/T_{t+2.5}$
$CDR_t = D_t/T_{t+2.5}$
$NMR_t = N_t/T_{t+2.5}$
$CWR_t = N_{t0}/EN_{tx}$, x = a to b

Net Migration

Where, m_x is age pattern of migration

M = estimated net migration for time t

N_{tx} = Population age x at time t

Then, $N_{tx} = N_{tx} + M_t*.5*m_x$
$N_{t+5,x} = N_{t+5,x} + M_t*.5*m_x$

Net Migration adjustment

Where, M_{tz} = adjustment for Migration at time t

M_{0z} = adjustment for Migation for every time t

M_{tf} = migration adjustment factor type at time t

When, M_{tf} = "*", $M_t = M_{tz} * T_t$ Else $M_t = M_{tz}$

And when, $M_{0z} < 1.5$ and $M_{0z} > 0$,

$M_t = M_t * M_{0z}$ Else $M_t = M_t + M_{0z}$

Total population adjustment

Where, T_{tf} = "*", $T_t = T_t * T_{tz}$

T_{tf} = "=", $T_t = T_{tz}$

T_{tf} = "+", $T_t = T_t + T_{tz}$

T_{tf} = "-", $T_t = T_t - T_{tz}$

Then, $T_t = T_t + M_t * .5$

Birth adjustment

Where, B_{tf} = "*", $B_t = B_t * B_{tz}$

B_{tf} = "=", $B_t = B_{tz}$

B_{tf} = "+", $B_t = B_t + B_{tz}$

B_{tf} = "-", $B_t = B_t - B_{tz}$

Death adjustment

Where, D_{tf} = "*", $D_t = D_t * D_{tz}$

D_{tf} = "=", $D_t = D_{tz}$

D_{tf} = "+", $D_t = D_t + D_{tz}$

D_{tf} = "-", $D_t = D_t - D_{tz}$

Converting estimated crude rates to counts of births and deaths

Where $B_t < 1.$ And $D_t < 1.$, $R_t = EXP((LOG(1.+B_t-D_t)))*2.5)$

Where $B_t < 1.$ And $D_t => 1.$, $R_t = EXP((LOG(1.+B_t-(D_t/T_t)*.2))*2.5)$

Where $B_t > 1.$ And $D_t < 1.$, $R_t = 1.$

Then,

Births from birth rates: $B_t = T_t * B_t * R_t * 5$

Deaths from death rates: $D_t = T_t * D_t * R_t * 5$

Interpolation of birth, death, or migration counts or rates

Where, k = births, deaths or migration

A_{tk} = adjustment value for variable k at time t

O_{tk} = operand for value of variable k at time t

r = previous time when $A_{tk} <> 0$; $r < t$

s = next time when $A_{tk} <> 0$; $s > t$

When, $A_{tk} = 0$, then $O_{tk} = O_{rk}$

If $O_{rk} = O_{sk}$, $A_{tk} = A_{rk} + ((EXP((LOG(A_{sk})-LOG(A_{rk}))/(s-r))))*(t-r)$

If $O_{rk} <> O_{sk}$, $A_{tk} = A_{rk}$

*Migration estimated from total population*Where, p = total population

When, $A_{.p}$ is active, and $A_{tp} > 0$

Then, approximate annual migration rate for t

$M_t = (((T_t-A_{tp})/(t-r))/((T_{t+5}+A_{tp})*.5))/5$

And, total population for t becomes, $T_t = A_{tp}$

7. Glossary.

Explanation of symbols. Commands begin with upper case italics characters. Keystrokes required to activate a command consist of a series of words beginning with these characters, listed in order from the main menu. Commands for the corresponding help screens containing additional information are fully italicized. Named keys are bracketed by carets < >. Press the key to carry out the command.

<ESC> Escape to the main *POPULATE* menu. Press the *<ESCAPE>* key.

<ESC><ESC><ESC> Escape from any tutorial that may be active.

<ENTER> Accept the requested data. Press *<ENTER>* or *<RETURN>*.

<SPACEBAR> Move one space toward the main menu. Press *<SPACEBAR>*.

<TAB> Tab forward in the current help screen or lesson.

<BACKSPACE> In learn mode, move one step backward in the lesson.

<F1> Edit the currently selected variable. See edit.

<CTRL><SHIFT><PRINT SCREEN> Print currently displayed text. See print, *HERCULES*.

<!> Turn the recorder on. See record.

<\> Pause the recorder.

0q mortality quotient for the year of life following birth. *Statistics*.

Active any currently selected feature or variable, "!", used in projecting a model. *If Variable. Basics Options If Adjust Edit View*

Adapter the hardware used to display information on the screen. *POPULATE* supports *C*ga, *E*ga, *M*dpa (standard PCs and XTs without graphics), *V*ga, and He*R*cules/Hercules+ adapter cards. Use *PINSTALL* to install *POPULATE* for most graphics systems. Configuration may be changed from within *POPULATE* by selecting *O*ptions *C*onfigure *A*dapter followed by a choice from the adapter menu. *O*ptions *I*nstall. *Ynstall Graphics*

Age Age statistics estimated for each quinquennium. *Statistics*.

Age variables (suppositions) about age structure of mortality, migration, fertility, or population. There must be at least 11 age groups for the first mortality, migration and population variables (0-4, 5-9...50+), and no more than 16 (...75+). Fertility ages require only 7 values (15-19, ...45-49). Age variables may be activated at the beginning of a model (*If Variable...*) or at any specified quinquennium (*If Age...*). *If Adjust Edit*

Axis Extends or contracts the vertical axis for displaying any statistic. Press Options Axis, select a statistic, then enter an adjustment factor. Values greater than 1 extend the range; less than one contract it. To contract the range of birth rates from 0-99 to 0-33, press *O A B .33<ENTER><ESC>*. To Restore original axes, press *O A R*. *Options*

Birth Specified series of births, or birth rates, as read into the program from the input data file. *Data Files Xample*

Chart plot graphics data on a dot-matrix printer (only on graphics systems). For Chart to function as expected, the system must be fully IBM-PC compatible (not *HERCULES*), the printer turned on, and the operating system program *GRAPHICS* run before starting *POPULATE*. Options Chart. *Chart*

Child/woman ratio	See Cwr.
Color	available on color graphics systems. Background and graphics colors are available, depending upon installation. Statistics are displayed in a rainbow, each statistic with a unique color. To change color for individual statistics, select run *PINSTALL*, select Color; set background color, then statistics and colors from the displayed menus. To change color from within *POPULATE*, select Options Configure Color. *Install Options Color. Ynstall*
Common Commands	15 actions or functions invoked from the Main, If or Options Menus: File Graphics Help IF Models Note Options Quit Record Statistics Tables View Wipe Zoom
Configure	*POPULATE* for text or graphics adapter card, or change color or monochrome settings. Options Configure Adapter Color Monochrome.
Constant	set constant demographic parameters to be applied to a model. Birth rate, Death rate, Migration, or Initial population. This feature permits across-the-board adjustments to be quickly specified. *If Constant... If Adjust*
Continue	Press <*SPACEBAR*> or an unassigned key at any menu to continue to the next menu. <*ENTER*> is synonymous with <*SPACEBAR*>, except when editing, where <*ENTER*> moves the cursor forward without continuing to the next menu.
Core menus	Three main menus: Populate, Options, If.
Cwr	child woman ratio statistic: children aged 0-4/women aged 15-49, computed from age estimates for each quinquennium. *Statistics.*
Data	information used to calculate a demographic model. A *POPULATE* data file consists of title, year instruction line, series of births and deaths (either counts, estimates, or rates); optional instructions include survival probabilities, net migration estimates (or rates), age structure, fertility structure, or migration age structure. As many as 40 variables may be referenced in a single file. The default file name is xxx.*POP*. *Data Files*
Death	series of deaths (counts or estimates), or annual death rates (less than 1, greater than zero), read into the program from the input data file. *Data Xample*
Edit	quinquennial or age variables. To edit a variable, press: *If Variables* {toggle the hotkey of the desired variable} <*F1*>. Then move, the arrow keys to the desired period, type in any operand and value, and press <*ENTER*>. Tap the <*SPACEBAR*> to exit the editor. *Edit*
Escape	Press the <*ESC*> key to escape directly to the main menu. When in Learn mode, press <*ESC*> repeatedly to escape from a lesson (or press *L* at the main menu).
File	When on, results of each projection are automatically written to the output file. Options File. *Options*
Graphics	plot demographic statistics on the screen (when supported by the computer system and installed by *PINSTALL*). To turn on at the main or Options menus, press *G*. Press *G* again to turn graphics off (and tables on). When graphics are on "!", press *T* to display statistical tables. *Graph View*

Grr — gross reproduction ratio, a fertility statistic: total births in each quinquennium are distributed according to weights from the currently active fertility schedule, summed, and divided by the total female population aged 15-49. Four age schedules are included in *POPULATE*: mean age of childbearing of 27, 29, 31 and 33 years. Any one of these may be activated for any particular quinquennium. *Statistics*

Help — definitions of terms available at any menu, by pressing *H*. Press *H* again for a menu and description of all *H*elp screens. Press *<TAB>* to skip a screen, *<SPACEBAR>* to return. *Help*

HERCULES/HERCULES^{+} — adapter card. To obtain graphics on a *HERCULES* or *HERCULES*$^{+}$ system a special *POPULATE* file must be prepared by means of the program *POPHERC*. After running *POPHERC* once, subsequently invoking *POPULATE* will first load a *HERCULES* graphics driver (*HERC.COM*), then *POPULATE*. Neglecting to run *POPHERC*, produces graphics junk (without damaging any hardware; just *Q*uit, then run *POPHERC*). After quitting *POPULATE*, if you intend to work with another program which uses graphics (and wish to guarantee that no stray graphics interface instructions are hanging around in memory), restart the computer by turning the power off or rebooting. Should the *HERCULES* card be replaced by a conventional adapter card, reinstall *POPULATE*, by running *UNHERC* then *PINSTALL*. To obtain printed copies of *POPULATE* text screen from a *HERCULES* card, select *<ESC>* *O*ptions *C*onfigure *A*dapter *M*dpa *<CTRL>* *<SHIFT>* *<PRINT>* *<SCREEN>*. To reconfigure for Hercules graphics, select *O*ptions *C*onfigure *A*dapter he*R*cules. These complications are wholly irrelevant for those have never heard of (and presumably do not use) a *HERCULES* adapter card. *Ynstall*

Hotkey — first letter of a command word, which when pressed triggers the corresponding action. Press *<SPACEBAR>* to continue, *<ESC>* to escape to the main menu. Press *H, N, Q, W* at any time for *H*elp (explanation of commands), make a *N*ote in the results file, *Q*uit the program, or *W*ipe the screen. *<CTRL>* *<SHIFT>* *<PRINT SCREEN>* prints the current screen display on a dot-matrix printer. *!* - toggles the recorder on and off. ** - pauses the recorder. *Basics*

IF — begin a sequence of menus to activate or edit variables and specify conditions of a model or projection. *If Adjust*

*I*nfant mortality rate — Number of deaths under one year of age per 1000 annual births.

Install — required to display graphics or colors on systems which support these features. For text systems no installation is needed. For Hercules cards, run *POPHERC*. For all others use *PINSTALL*. *Ynstall*

Interpolation — null data values of active birth, death, or migration variables are estimated as the logarithmic average between two specified data points. This is the optimal solution for all variables except total population size, where population totals are simply reset, and any difference between projected and set is attributed to migration.

K — relative mortality variability. *Statistics*.

*L*abels — numeric and alphabetic tags which identify models, statistics, and scales of data displayed graphically. *Options Chart*

*L*earn — begin a tutorial with recorded lessons from a *xxx.LRN* file. The command screen expands to permit an additional line of instructions to be displayed with each menu. *Learn*

Life	life expectancy at birth computed from the total number of deaths for a quinquennium and distributed according to weights derived from the difference between survival probabilities for two life tables of the same region and closely similar levels. *If Lifetable. Statistics. If Adjust*
Lifetable	survival probabilities for 24 mortality levels (life expectancy at birth from 20 to 77.5 years) and four regions (West South North East). *If Lifetable* (activates the selected mortality and age structure) or *If Variable Lifetable* (activates and allows one to view or the expert to edit lifetable values.) Editing is not recommended. Instead, prepare survival probabilities and include in the data file. *If Adjust*
Migration	net migrants, or migration rates, as read into the program from the input data file. "-nnn" indicates net outmigration, and +nnn, in-migration; "*nnn", migration rate. When *nnn is less than one, the net migration rate is outward; *nnn greater than one signifies net in-migration. *Statistics. If Variable... Data If Adjust.* See out migration.
Model	a projection defined by active variables (initial population size, birth and death series, migration estimates, and any age structures) and constants. Statistical results include population size, crude birth and death rates, life expectancy, gross reproduction ratio, etc. To review a list of models and their specifications, press Options Model. *Statistics Results*
Monochrome	default "color" unless installed otherwise. *PINSTALL INSTALL. Ynstall*
Net Reproduction Ratio	The proportional population change per generation; calculated here as the product of the gross reproduction rate and the probability of survival to the mean age of childbearing.
Note	type a note to the current results file. Available at any menu, but not while calculating, editing, or entering a response. *Basics*
Operand	See adjust, edit, data. *Data Adjust*
Options	menu to change the statistics displayed or the way information appears on the screen. *Options*
Out migration rate	estimates or counts of out-migrants in each quinquennium, distributed according to age weights either from data input or those from within the program. When the number of out-migrants for an age group exceeds one-half of the number of people for that age group, a message appears at the bottom of the screen. Corrective action: review the statistical results for the quinquennium in which this occurred to pinpoint the problem (too few births, too many deaths or migrants). Carefully check the values of each variable used in the projection (including operands). Except in the most mobile populations, one would normally expect "migrations" of such magnitude to be due to a typing mistake, either of some value or its operand. *Data Edit Results*
Output	results written to a disc file. *Results Files*
Pause	interrupt the recording of a tutorial's key strokes, by pressing <\>. Press <\> again to resume.
POPULATE	calculate a model using the currently specified If conditions: birth and death series, life tables, age structures, constants, etc. *POPULATE Basics*
Populating...	results are being calculated for the current model. The keyboard is turned off while calculations proceed.
Population	totals at the beginning of a model (If Constant) or mid-quinquennial estimates. *Statistics Results*

Print screen	Print information from the screen to the printer. While pressing the <*CTRL*> and <*SHIFT*> keys, tap <*PRINT SCREEN*>. See also *HERCULES*.
Px	age specific survival probabilities from a life table. Two sets are expected in the data file (for ages 0, 1-4, 5-9...last age group), but they may also be selected from the 192 model life tables (96 unisex, 96 female) included in the file *POPULATE.LIF*. *If Adjust Data*
Quit	close the results file, stop the session, and exit *POPULATE*.
Qx	1-Px. See Px.
Record	procedure to create a lesson, that is, record a series of commands or keystrokes and save them to file xxx*.LRN*. Use record to prepare a tutorial. Begin recording a lesson, by typing <*!*> or *O*ptions *R*ecord. Finish a lesson by typing <*!*>. As each hotkey is stroked, type a brief message or additional prompt, which will appear as the lesson is played back by the student. To pause recording press <\>, and <\> again to restart. Use <*SPACEBAR*> to return from a menu, or <*ESC*> to jump to the main menu. To reduce the number of prompts at playback where multiple strokes are desired from a single menu, pause the recorder, tap the desired strokes, start the recorder again, press <*SPACEBAR*> and type a single message explaining all the expected strokes. *.LRN* files may be edited using any editor which does not place odd formating commands in the file. *O*ptions. *Learn*
*R*einstall	continue installing the system. *PINSTALL I*nstall. *Ynstall*
*R*estore	values of data constants or axes to their initial settings. *If C*onstant *R*estore. *O*ptions *A*xes *R*estore. *If Options*
Space	Press the <*SPACEBAR*> to continue from one menu to another.
*S*umages	Cumulative age distribution. *Statistics*.
*T*ables	display demographic statistics on the screen as tables. To display graphics on the screen (of systems which support this), press *G*. To view the statistical results from many models, select *V*iew *L*ist {select desired models} <*SPACEBAR*> {select desired statistics}. *O*ptions. *View Results*
Teach	See record. *Learn*
Toggle	Turn a variable or option on or of by pressing its hotkey.
Universal keys	may be activated at any menu: <*ESC*>, <*SPACEBAR*>, *H*elp, *N*ote, Quit, *W*ipe, {<*CTRL*><*SHIFT*><*PRINT SCREEN*>}, <*!*>, and <\>.
*V*ariable	an array of demographic information (births, deaths, age patterns of fertility or mortality, migration, etc.). Variables are used to calculate results for a model specified by *If V*ariable and *If A*ge. Active variables are checked," !". *If Adjust Data Files Edit*
*V*iew	display one or more models or statistics on the screen. *V*iew
*W*ipe	clear the screen of all information and display the next menu. *Basics*
Ynstall	See *INSTALL*. *Ynstall*
*Z*oom	change the display so that data are displayed from xxx to yyy at intervals of zzz (5-50 years). *O*ptions. *View*