URBAN POPULATION DYNAMICS

1. Using the information given to us in the matrix, it is easy to see that the data in the matrix is parallel to a human society in a practical sense. The population in 2000 is as follows:

|  |  |
| --- | --- |
| Age Group | Population Distribution |
| 0-9 | 210,000 |
| 10-19 | 190,000 |
| 20-29 | 180,000 |
| 30-39 | 210,000 |
| 40-49 | 200,000 |
| 50-59 | 170,000 |
| 60-69 | 120,000 |
| 70-79 | 90,000 |
| 80+ | 50,000 |

All this information is given through the vector x(0). The Leslie matrix also contains a lot of information: it explains the survival rate of an age group to advance to the next age group. The top row of the Leslie matrix describes fecundity – per capita average number of female off springs reaching the age group 0-9 from mothers of the current age group they represent.

In this particular example, the population appears to have a large population of children 0-9 and 30-39 year-old adults. Social factors that influence the downward trend of the distribution would be because of time. The real-life model shows that the population of the generation group shrinks the later they live for. This is only natural due to death. The Leslie Matrix shows that most children are born from mothers of the 10-19 year old column, with 20-29 and 30-39 following closely behind. The number falls off for further columns due to woman’s inability to produce children at a later age. Lastly, the Leslie Matrix shows the percentage of people who survive from one age group to the next. Because children are more prone to put themselves in danger, they have 70% chance of surviving until age 10 in this particular population. It remains fairly steady later in life, peaking at 20-29 and 30-39. Later in life (closer to 60-69 and 70-79) the numbers begin shrinking again, with only 77% of 60-69 year olds living until 70, and only 40% of 70-79 year olds living until 80. This is again due to the fragility of the human condition at this age. We are more prone to diseases and health problems the older we get, increasing the chances of death.

1. Using power\_method.java, one can determine the population distribution in years 2010, 2020, 2030, 2040, 2050, etc.

**2010: Loop 1 2020: Loop 2**

|  |  |
| --- | --- |
| 0-9 | 635,000 |
| 10-19 | 147,000 |
| 20-29 | 161,500 |
| 30-39 | 162,000 |
| 40-49 | 189,000 |
| 50-59 | 176,000 |
| 60-69 | 138,000 |
| 70-79 | 92,000 |
| 80+ | 36,000 |

|  |  |
| --- | --- |
| 0-9 | 518,750 |
| 10-19 | 444,500 |
| 20-29 | 124,950 |
| 30-39 | 145,350 |
| 40-49 | 145,800 |
| 50-59 | 166,320 |
| 60-69 | 140,800 |
| 70-79 | 104,720 |
| 80+ | 36,960 |

**2030: Loop 3 2040: Loop 4**

|  |  |
| --- | --- |
| 0-9 | 816,240 |
| 10-19 | 363,124 |
| 20-29 | 377,825 |
| 30-39 | 112,455 |
| 40-49 | 130,815 |
| 50-59 | 128,304 |
| 60-69 | 133,056 |
| 70-79 | 108,416 |
| 80+ | 41,888 |

|  |  |
| --- | --- |
| 0-9 | 965,648 |
| 10-19 | 571,367 |
| 20-29 | 308,656 |
| 30-39 | 340,042 |
| 40-49 | 101,209 |
| 50-59 | 115,117 |
| 60-69 | 102,643 |
| 70-79 | 102,453 |
| 80+ | 43,366 |

**2050: Loop 5 Population Totals**

|  |  |
| --- | --- |
| 0-9 | 1,341,322 |
| 10-19 | 675,953 |
| 20-29 | 485,662 |
| 30-39 | 277,790 |
| 40-49 | 306,038 |
| 50-59 | 89,064 |
| 60-69 | 92,093 |
| 70-79 | 79,035 |
| 80+ | 40,981 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **2010** | |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1,736,500 |  |  |  |  | |
| **2020** | 1,828,150 |
| **2030** | 2,212,123 |
| **2040** | 2,650,501 |
| **2050** | 3,387,938 |

|  |  |
| --- | --- |
| Year Range | Fractional Change: |
| 2000-2010 | 22.2887323943662% |
| 2010-2020 | 5.277857759861791% |
| 2020-2030 | 21.00336405655991% |
| 2030-2040 | 19.81707165469551% |
| 2040-2050 | 7.822551283700705 |

**Percent Increase in Total Population**

1. The dominant eigenvalue for this situation is estimated to be 1.2886562339310283. This is the population’s growth rate at the stable age distribution, which is given by the eigenvalue’s corresponding eigenvector:

72.77316642479103

39.53049320372915

26.07438534687458

18.210401031935042

12.718179214285893

8.685014213938615

5.391671718341888

3.221640584827573

1.0

The population becomes stable in the long run since the values converge (||Ak||) under the tolerance after 86 iterations. In every iteration, we get closer and closer to the eigenvalue and eigenvector. This is due to the decreasing difference between k+1 and k in the equation n(k + 1) = An(k). As the value gets smaller and smaller, the difference between each iteration lessens, eventually falling beneath an error threshold.

1. In 2020, we cut the second age group’s birth rate in half. The year 2020 corresponds with x(2):

5.1875

4.445

1.2495

1.4535

1.4580000000000002

1.6632

1.4080000000000001

1.0472000000000001

0.3696

The birth rate of the second age group is 1.2 (This is the second column of the first row). Cut in half, it is merely .6. Ran through our program this changes the following

**2030:**

|  |  |  |
| --- | --- | --- |
| Age Groups | Pre-Change | Estimated Population |
| 0-9 | 816,240 | 549,540.0000000001 |
| 10-19 | 363,124 | 363,124.99999999996 |
| 20-29 | 377,825 | 377,825.00000000003 |
| 30-39 | 112,455 | 112,455.00000000002 |
| 40-49 | 130,815 | 130,815.00000000001 |
| 50-59 | 128,304 | 128,304 |
| 60-69 | 133,056 | 133,056.00000000002 |
| 70-79 | 108,416 | 10,841.6 |
| 80+ | 41,888 | 41,888 |

**2040:**

|  |  |  |
| --- | --- | --- |
| Age Groups | Pre-Change | Estimated Population |
| 0-9 | 965,648 | 747,773.5000000001 |
| 10-19 | 571,367 | 384,678.00000000003 |
| 20-29 | 308,656 | 308,656.24999999994 |
| 30-39 | 340,042 | 340,042.50000000003 |
| 40-49 | 101,209 | 101,209.50000000002 |
| 50-59 | 115,117 | 115,117.2 |
| 60-69 | 102,643 | 102,643.2 |
| 70-79 | 102,453 | 102,453.12000000002 |
| 80+ | 43,366 | 43,366.400000000005 |

**2050:**

|  |  |  |
| --- | --- | --- |
| Age Groups | Pre-Change | Estimation Population |
| 0-9 | 1,341,322 | 886,487.8749999999 |
| 10-19 | 675,953 | 523,441.4500000001 |
| 20-29 | 485,662 | 326,976.3 |
| 30-39 | 277,790 | 277,790.62499999996 |
| 40-49 | 306,038 | 306,038.25000000002 |
| 50-59 | 89,064 | 89,064.36000000002 |
| 60-69 | 92,093 | 92,093.76000000001 |
| 70-79 | 79,035 | 79,035.264 |
| 80+ | 40,981 | 40,981.24800000001 |

The estimated eigenvalue is 1.1679027367203167

The estimated eigenvector is:

33.12287674923348

19.85269234813984

14.448796090175751

11.134417338052286

8.580316912747959

6.465160707465589

4.428561046281154

2.9197568412193515

1.0

In the long run, this will not affect age groups who were born past 2020. As time goes on, there is a huge deficit between the two situations. As previously mentioned, the eigenvector represents the growth rate at the stable age distribution. The new matrix’s eigenvector is smaller. In the long run, the population will grow slower than the old matrix.