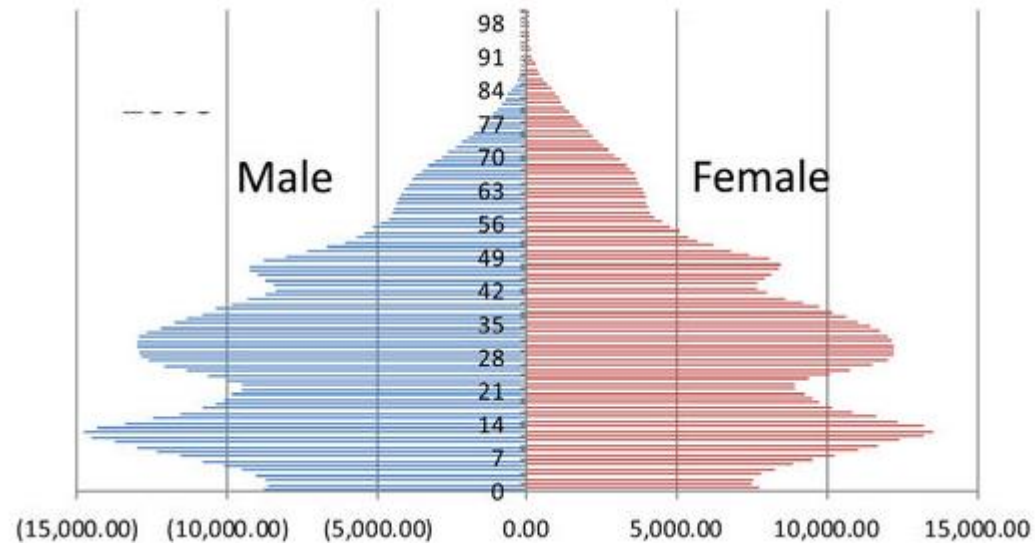
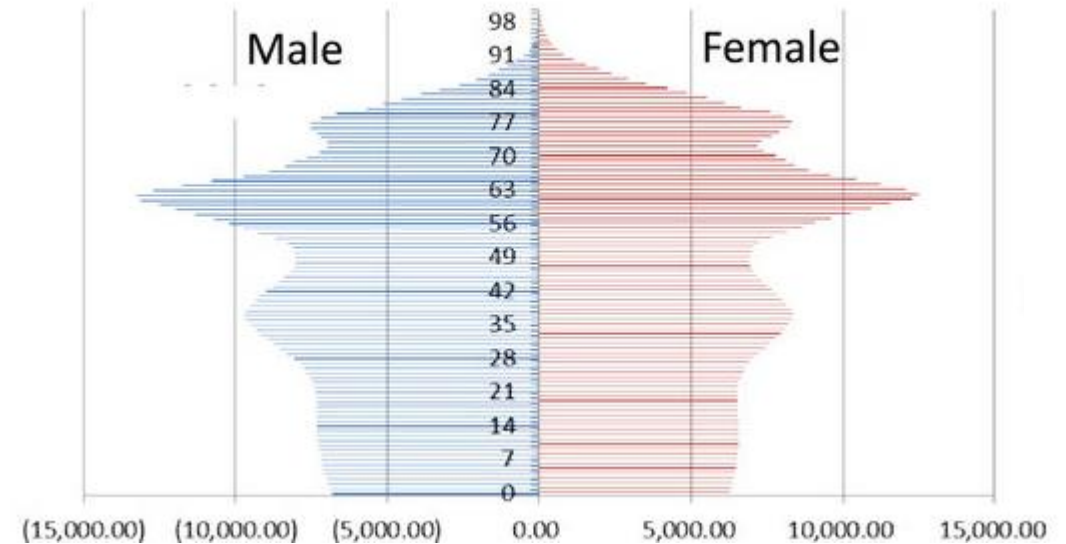


Which national population will grow faster?



China (2000)



China (predicted 2050)

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix}$$

Three age classes:

- First Year (FY)
- Second Year (SY)
- Adult

Contributions from FY $N_t \dots$
Contributions from SY $N_t \dots$
Contributions from Adult $N_t \dots$

$$\left[\begin{array}{c|c|c} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{array} \right]$$

Contributions from FY $N_t \dots$
 Contributions from SY $N_t \dots$
 Contributions from Adult $N_t \dots$

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ \hline S_1 & 0 & 0 \\ \hline 0 & S_2 & S_3 \end{bmatrix} \begin{array}{l} \dots \text{ add to FY } N_{t+1} \\ \dots \text{ add to SY } N_{t+1} \\ \dots \text{ add to Adult } N_{t+1} \end{array}$$

Contributions from FY $N_t \dots$
 Contributions from SY $N_t \dots$
 Contributions from Adult $N_t \dots$

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ \hline S_1 & 0 & 0 \\ \hline 0 & S_2 & S_3 \end{bmatrix} \begin{array}{l} \dots \text{ add to FY } N_{t+1} \\ \dots \text{ add to SY } N_{t+1} \\ \dots \text{ add to Adult } N_{t+1} \end{array}$$

Example A: FY population size in N_{t+1} is the sum of FY, SY, and Adult reproduction in N_t

Contributions from FY $N_t \dots$
 Contributions from SY $N_t \dots$
 Contributions from Adult $N_t \dots$

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ \hline S_1 & 0 & 0 \\ \hline 0 & S_2 & S_3 \end{bmatrix} \begin{array}{l} \dots \text{ add to FY } N_{t+1} \\ \dots \text{ add to SY } N_{t+1} \\ \dots \text{ add to Adult } N_{t+1} \end{array}$$

Example B: SY population size in N_{t+1} is equal
 to FY survival (S_1) times the number of FY
 individuals in N_t

What would it look like if the first age class wasn't reproductive?

Contributions from FY $N_t \dots$
Contributions from SY $N_t \dots$
Contributions from Adult $N_t \dots$

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix} \begin{array}{l} \dots \text{ add to FY } N_{t+1} \\ \dots \text{ add to SY } N_{t+1} \\ \dots \text{ add to Adult } N_{t+1} \end{array}$$

What would it look like if the first age class wasn't reproductive?

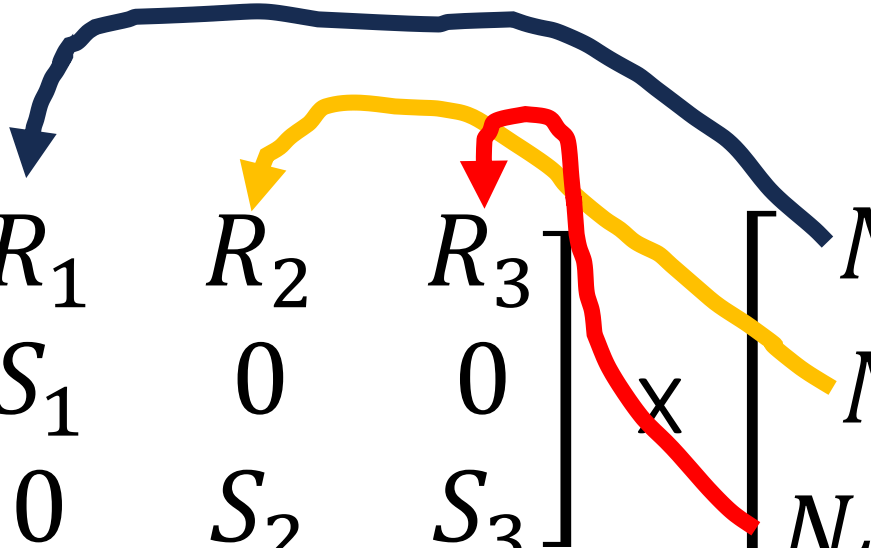
Contributions from FY $N_t \dots$
Contributions from SY $N_t \dots$
Contributions from Adult $N_t \dots$

$$\begin{bmatrix} 0 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix} \begin{array}{l} \dots \text{ add to FY } N_{t+1} \\ \dots \text{ add to SY } N_{t+1} \\ \dots \text{ add to Adult } N_{t+1} \end{array}$$

Basics of matrix multiplication

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix} \times \begin{bmatrix} N_t (FY) \\ N_t (SY) \\ N_t (Adult) \end{bmatrix} =$$

Basics of matrix multiplication



The diagram illustrates the process of matrix multiplication between two 3x3 matrices. The first matrix on the left has rows labeled $R_1, S_1, 0$ and columns labeled $R_2, 0, S_2$. The second matrix on the right has rows labeled $N_t(FY), N_t(SY)$ and columns labeled $N_t(Adult)$. Colored arrows show the dot products for each row of the first matrix with the columns of the second matrix: a blue arrow from R_1 to $N_t(FY)$, a yellow arrow from S_1 to $N_t(SY)$, and a red arrow from 0 to $N_t(Adult)$. The multiplication is represented by a large 'x' between the matrices, followed by an equals sign.

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix} \times \begin{bmatrix} N_t(FY) \\ N_t(SY) \\ N_t(Adult) \end{bmatrix} =$$

$$\begin{bmatrix} R_1 & R_2 & R_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & S_3 \end{bmatrix} \times \begin{bmatrix} N_t(FY) \\ N_t(SY) \\ N_t(Adult) \end{bmatrix} =$$

$$\begin{bmatrix} R_1 * N_t(FY) & R_2 * N_t(SY) & R_3 * N_t(Adult) \\ S_1 * N_t(FY) & 0 & 0 \\ 0 & S_2 * N_t(SY) & S_3 * N_t(Adult) \end{bmatrix}$$

What goes into the R term?

- R : reproductive contribution from a given age class to the initial age class (which, in our case, is FY)
- To join the FY age class, individuals must do two things:
 - Be born/hatched
 - Survive until the time of the survey
- These two metrics are represented by the symbols F , representing fecundity, and S_0 , representing initial survival
 - $R_1 = F_1 * S_0$

Final notes

- This lab can be done on Mac computers (doesn't require MARK)
- Extra credit is available for this lab
 - Translate Part 3 from Excel to R