Your Task: A Population Model

When studying the environment, scientists sometimes look at how population sizes of animals and plants change over time. The scientists can use this information to find out which species are in danger of becoming extinct, to predict the effect of introducing a foreign species of animal into the countryside, or to discover the effect of a pollutant.

Studying populations of animals and plants in the wild can take a very long time, so scientists use computer models to help them in their studies.

You have been asked to create a simple population model to investigate how a greenfly population changes. Greenflies are a common insect that are considered to be a pest by gardeners because they damage roses and other garden plants.

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The photograph above shows a greenfly infestation on a rose bush.

The life cycle of greenfly is complex and the model you have been asked to create will model only some aspects of the greenfly life cycle. In the summer, the population consists only of females and each female gives birth only to females.

The Population Model rules

To create a population model, the following rules must be followed.

1. The population consists only of females.

2. At any one time there are three types of individual in the population:

    - Seniles – old greenfly that do not reproduce
    - Adults – greenfly that are reproducing
    - Juveniles – greenfly that are too young to reproduce.

3. The model lasts for a set number of **new** generations. At the end of each generation:

    - all surviving senile greenfly remain as seniles
    - all surviving adult greenfly change from adults to seniles

- all surviving juvenile greenfly change from juveniles to adults.

4. Each type of individual has a survival rate. The survival rate is used to calculate the number of individuals that survive at the end of each generation. This number can be a value between 0 and 1.

- A survival rate of 0 means no individuals of that type survive at the end of the generation.
- A survival rate of 1 means all the individuals of that type survive at the end of the generation.
- A survival rate of 0.25 means that a quarter of the individuals of that type survive to the next generation.

The number of individuals surviving to the next generation is calculated using the formula:

New number of individuals = Current number of individuals * survival rate

5. Adult greenfly have a birth rate. The birth rate is used to calculate the number of juveniles that adults produce each generation. This number can be a fraction, so a birth rate of 1.5 means that, on average, each adult produces 1.5 juveniles each generation.

The number of juveniles born each generation is calculated using the formula:

New number of juveniles = Current number of adults * birth rate

6. Numbers of individuals in the model are measured in thousands.

7. The following values must be set before the model is run:

- the initial numbers (called Generation 0) of juveniles, adults and seniles
- the birth rate and survival rates
- the number of **new** generations over which the model runs. This must be between 5 and 25.

Example data

Table 1 shows the data that are used by the model to generate the results in Figure 1.

Table 1

Type of greenfly	Initial population (1000s)	Survival rate
Juvenile	10	1
Adult	10	1
Senile	10	0

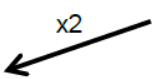Number of new generations = 5
Birth rate = 2

Figure 1 shows the way the model works for five new generations.

Figure 1
(population numbers are in thousands)

GENERATION	JUVENILES	ADULTS	SENILES	TOTAL
0	10	10	10	30
1	20	10	10	40
2	20	20	10	50
3	40	20	20	80
4	40	40	20	100
5	80	40	40	160

x2

Tasks

1. Develop a main menu for the program. The options on the main menu should be:

    - Set the Generation 0 values
    - Display the Generation 0 values
    - Run the model
    - Export data
    - Quit.

2. Develop the part of the program that allows the user to set the Generation 0 values for the:

    - population numbers of juveniles, adults and seniles
    - survival rates for juveniles, adults and seniles
    - birth rate
    - number of new generations to model. This should be between 5 and 25.

    The program should then return to the menu.

3. Develop the part of the program that will display the Generation 0 values for juveniles, adults and seniles, the birth rate and the survival rates. The program should then return to the menu.

4. Develop the part of the program that runs the model, displaying the number of juveniles, adults and seniles and the total population size for each generation from 0 to the number of new generations entered. The program should then return to the menu.

5. The model needs an export feature to save the data so that it can be used in another application (such as a spreadsheet package or CSV file). Click here for a suitable file.

    Develop your program so that when the user chooses to export the data:

    a) They are asked to enter a suitable filename
    b) The program should check whether a file of the same name already exists.
    c) If the file does not already exist, then the data are saved.
    d) If the file does already exist, the user should be asked whether they want to overwrite the existing file.
    e) If they choose to overwrite the existing file, then the data are saved.
    f) If they choose not to overwrite the existing file, then they should be returned to step a.

    After this option has been completed, the program should return to the menu.

6. In a real population, if the total population becomes too high, the survival rates will decrease because of disease.

    When the total population size reaches a disease trigger point, disease will take effect. When the total population size falls below this trigger point, disease will have no effect.

    The effect of disease is unpredictable. To simulate this effect a disease factor is applied to the survival rates of juveniles and seniles.

- The disease factor is represented by a random percentage between 20% and 50%.
- To calculate the new number of juveniles and seniles in the next generation, the following formula is used:

New number of individuals = Current number of individuals * survival rate * disease factor

Extend your menu from Task 1 to include an option to enter the total population disease trigger point.

Extend your program to allow for the effect of disease in calculating the population sizes. Disease will reduce the survival rates of juveniles and seniles **only**.

Submission

Design
Using the techniques, you have developed in your GCSE create a design for your project.
You should use a range of hierarchy charts, flowcharts and pseudocode.

Programming
Hand in a complete code listing, with comments to show you understanding of the code you have written.

Testing
If you have time develop and implement a test plan.

When you have finished add all of your work to a word document with your name in the file name and email it to: barry.cooper@cambridgeast.org.uk