Project 4

Colin Gibbons-Fly

The goal of this project is to model the population of rats at a local park in 2025 using the table of birth and survival rates given below. The average rat can live up to the age of 4. Below is a table of birth and survival rates for rats observed at the local park.

Age (years)	Birth Rate	Survival Rate	Population in 2019
0-1	0.00	0.90	610
1-2	0.65	0.97	750
2-3	0.55	0.95	640
3+	0.45	0.22	430

Objective

The goal of this activity is to estimate the total population of rats, across all age groups, at the local park in 2025 using the Table above, using a discrete-time population model.

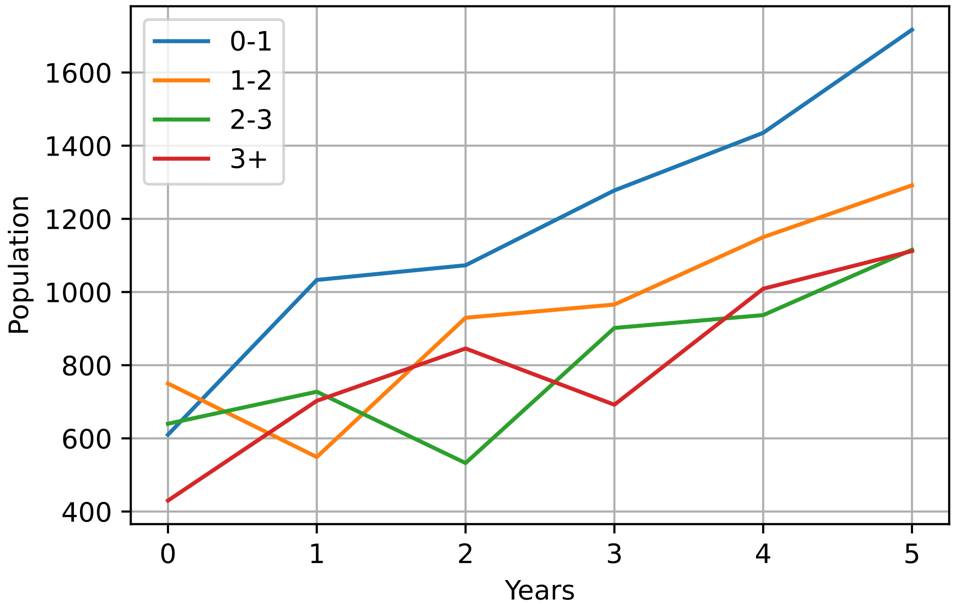
Hint: You can use the following steps:

1. Define four variables for the rats population in the different age groups, and assign the initial values from the table above. For example, 610 is the population of rats aged 0-1 in 2019, 750 is the population of rats aged 1-2 in 2019, and so on.
2. Write a recursive equation for each variable, using the birth and survival rates from the table above. What should the time step be for this model? For example, the population of rats aged 0-1 in 2020 is the sum of the baby rats (age 0-1) from the other three age groups based on their birth rates. Think carefully how the rats populations in age groups 1-2, 2-3 and 3+ change every time step based on the survival rates of the age groups.
3. Implement the system of four recursive equations in step (2) using a for loop to evolve the system over time, until the year 2025. What is the time step?
4. Find the total rats population in 2025, based on all four age groups.

The total rats population in 2025 should be about 6056 rats of all age groups.

```python
import numpy as np
import matplotlib.pyplot as plt
plt.clf()

# Given data
t = 2025-2019
r1 = np.empty(t)
r2 = np.empty(t)
r3 = np.empty(t)
r4 = np.empty(t)

r1[0] = 610  # rats 0-1 pop
r2[0] = 750  # rats 1-2 pop
r3[0] = 640  # rats 2-3 pop
r4[0] = 430  # rats 3+ pop

r1br = 0.00  # r1 birth rate
r2br = 0.65  # r2 birth rate
r3br = 0.55  # r3 birth rate
r4br = 0.45  # r4 birth rate

r1sr = 0.90  # r1 survival rate
r2sr = 0.97  # r2 survival rate
r3sr = 0.95  # r3 survival rate
r4sr = 0.22  # r4 survival rate

# Evolution of the system using a for loop
for i in range(t-1):
    r1[i+1] = r2br*r2[i] + r3br*r3[i] + r4br*r4[i]
    r2[i+1] = r1sr*r1[i]
    r3[i+1] = r2sr*r2[i]
    r4[i+1] = r3sr*r3[i] + r4sr*r4[i]

plt.plot(range(len(r1)),r1, label='0-1')
plt.plot(range(len(r2)),r2, label='1-2')
plt.plot(range(len(r3)),r3, label='2-3')
plt.plot(range(len(r4)),r4, label='3+')
plt.legend()
plt.grid()
plt.ylabel('Population')
plt.xlabel('Years')
```

```
plt.show()
```


0-1
1-2
2-3
3+
Population
1600
1400
1200
1000
800
600
400
0
1
2
3
4
5
Years