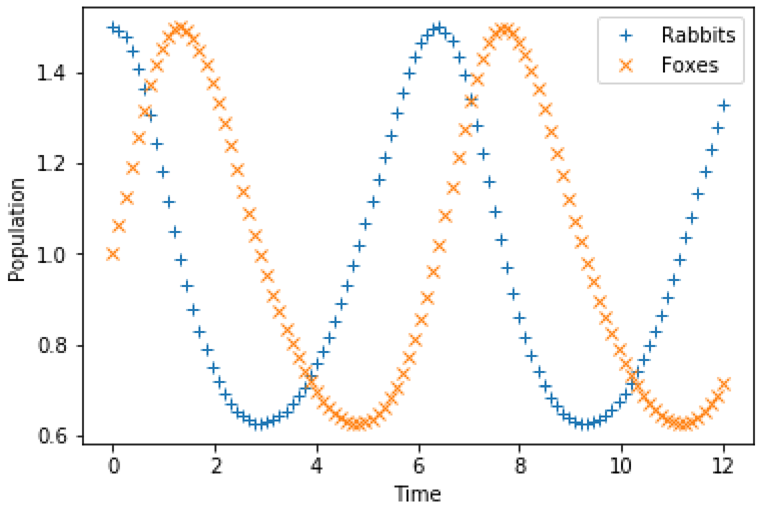
In [3]:

```python
# Ecuatiile Lotka-Volterra
# Modelul pradator-prada
# sistem de 2 EDO de ordinul intai neliniare
# reprezinta un model simplificat pentru schimbarea populatiei
# a doua specii care interactioneaza prin pradare
# exemple: vulpi (pradatori) si iepuri (prada)
# fie x - populatia de iepuri
# fie y - populatia de vulpi
# dx/dt=x(a-by)
# dy/dt=-y(c-dx)
# a, b, c, d, sunt parametri pozitivi

import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt

a,b,c,d = 1,1,1,1

# P=[x, y], P[0]=x, P[1]=y
# a, b, c, d may be optional arguments
def dP_dt(P, t):
    return [P[0]*(a - b*P[1]), -P[1]*(c - d*P[0])]

ts = np.linspace(0, 12, 100)
P0 = [1.5, 1.0]            # initial conditions
Ps = odeint(dP_dt, P0, ts)
prey = Ps[:,0]             # first column
predators = Ps[:,1]        # second column

plt.plot(ts, prey, "+", label="Rabbits")
plt.plot(ts, predators, "x", label="Foxes")
plt.xlabel("Time")
plt.ylabel("Population")
plt.legend();
```



In [4]:

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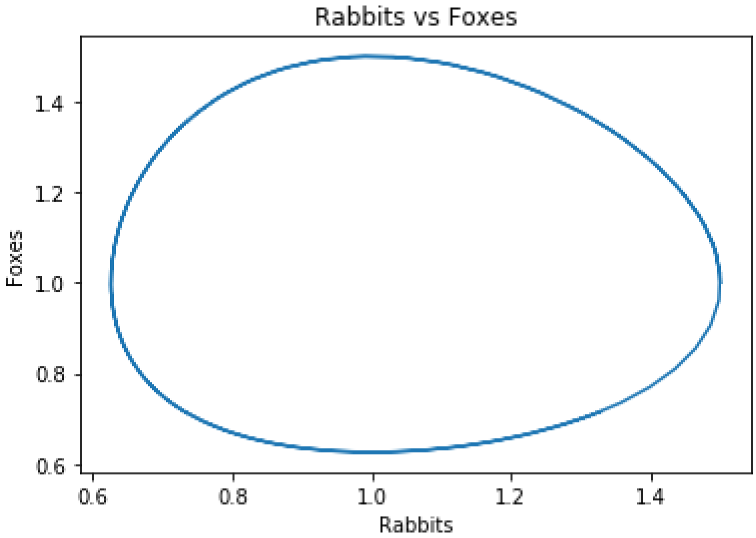
# Phase portrait: plot x vs y (instead of x, y vs t)
# One curve for each initial condition
# Curves will not cross, in general

plt.plot(prey, predators, "-")
plt.xlabel("Rabbits")
plt.ylabel("Foxes")
plt.title("Rabbits vs Foxes");
```



In [5]:

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# The plot above illustrates that the system is periodic.
# Let's plot a few more curves in the phase space.

ic = np.linspace(1.0, 3.0, 21)
for r in ic:
    P0 = [r, 1.0]
    Ps = odeint(dP_dt, P0, ts)
    plt.plot(Ps[:,0], Ps[:,1], "-")
plt.xlabel("Rabbits")
plt.ylabel("Foxes")
plt.title("Rabbits vs Foxes");

# Curves do not cross
# Closed curves <=> periodic solutions
# Equilibrium at x = y = 1 => dx/dt = dy/dt = 0
```

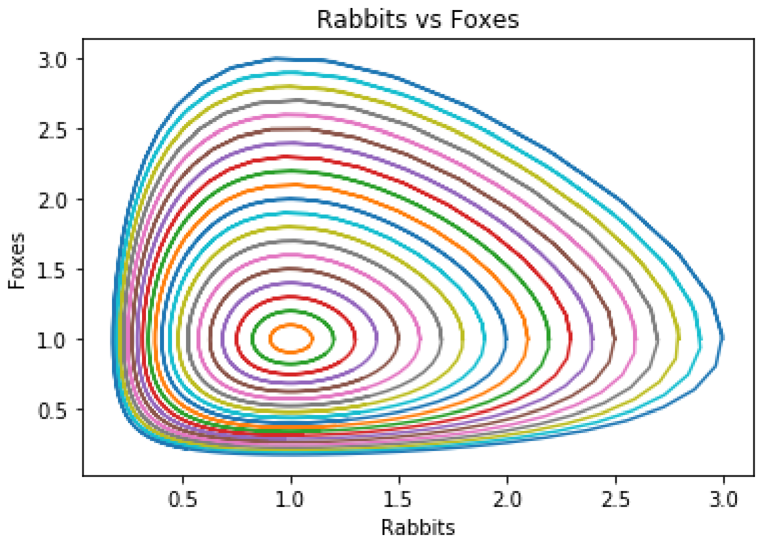

In [ ]:

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