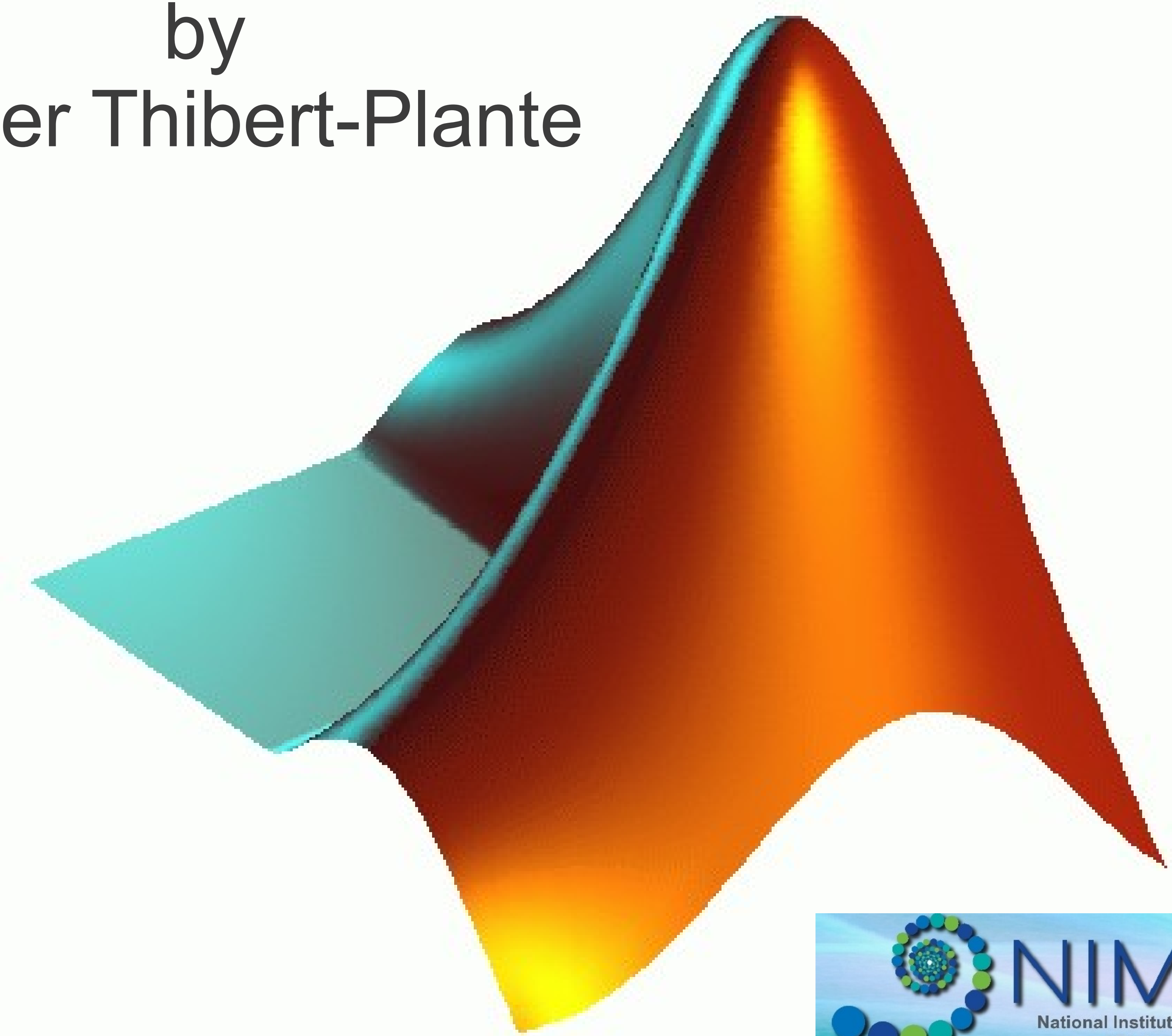
Matlab for REU
by
Xavier Thibert-Plante



NIMBioS
National Institute for Mathematical and Biological Synthesis

Plan

- Questions about the previous session
- Iterative process
- Logistic map
- Ordinary differential equation

Setup

- All the material is at http://nimbios.org/~xavier/REU2012/
- Create a directory for this session <workdir>
- Download all the relevant material to <workdir>
- Open Matlab
- Set the working directory to <workdir>

Iterative process

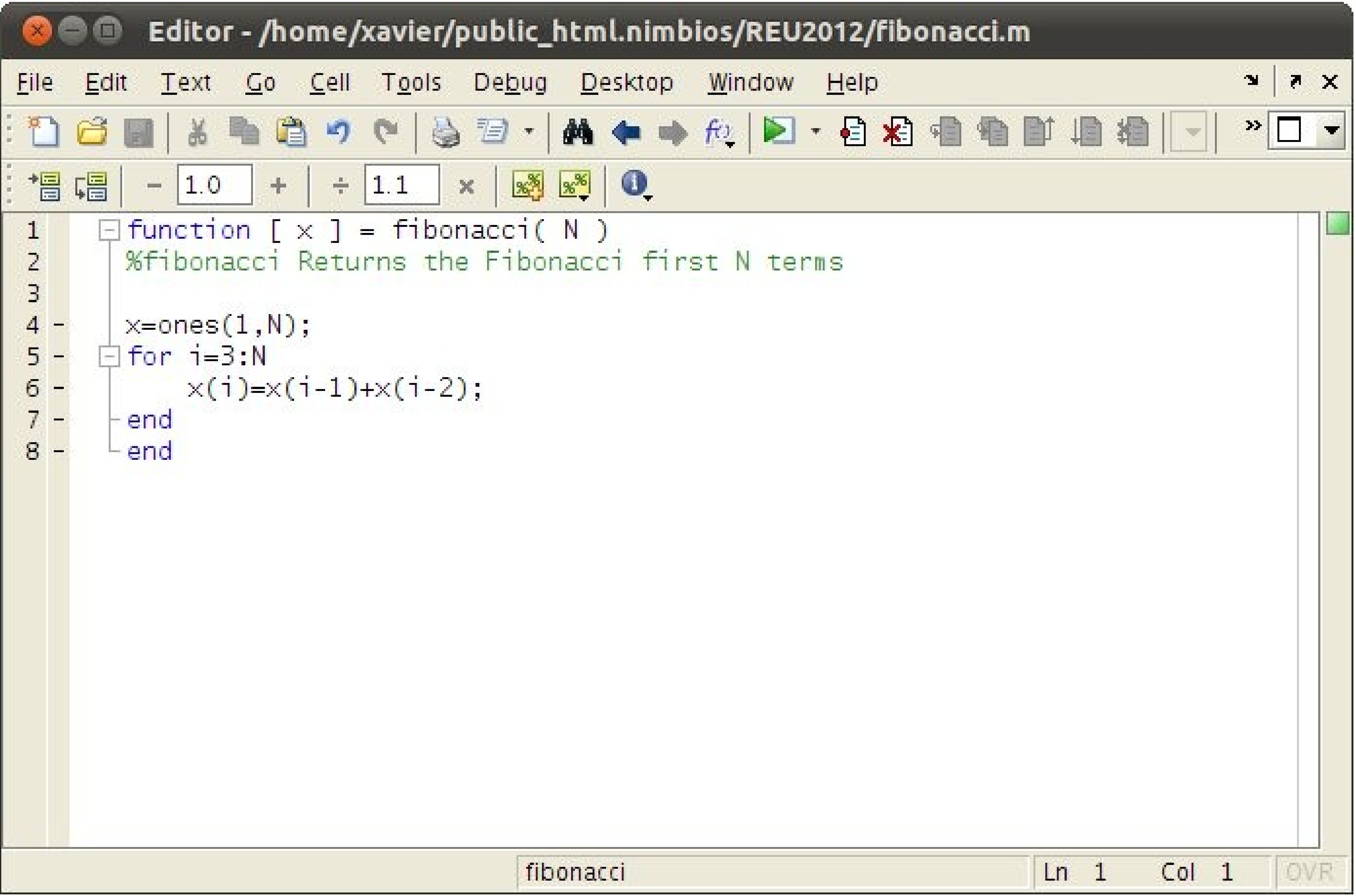
- Lets count rabbits

$$F_n = F_{n-1} + F_{n-2}$$

- Fibonacci number

$$F_1 = F_2 = 1$$

Picture from Wikipedia



```
function [ x ] = fibonacci( N )
%fibonacci Returns the Fibonacci first N terms

x=ones(1,N);
for i=3:N
    x(i)=x(i-1)+x(i-2);
end
end
```

Exercise

- Plot the ratio

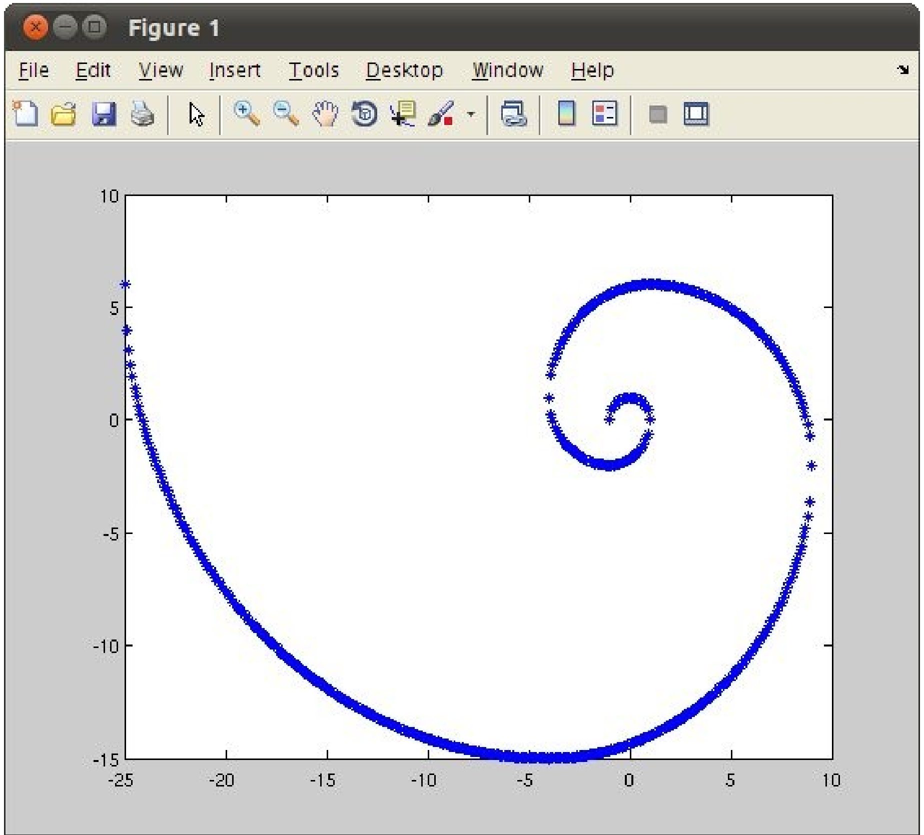
$$R_n = \frac{F_n}{F_{n-1}}$$

- What do you observe?

I converges to the golden ratio

$$\psi = \frac{1+\sqrt{5}}{2} \approx 1.618$$

- Which may remind you of the golden spiral



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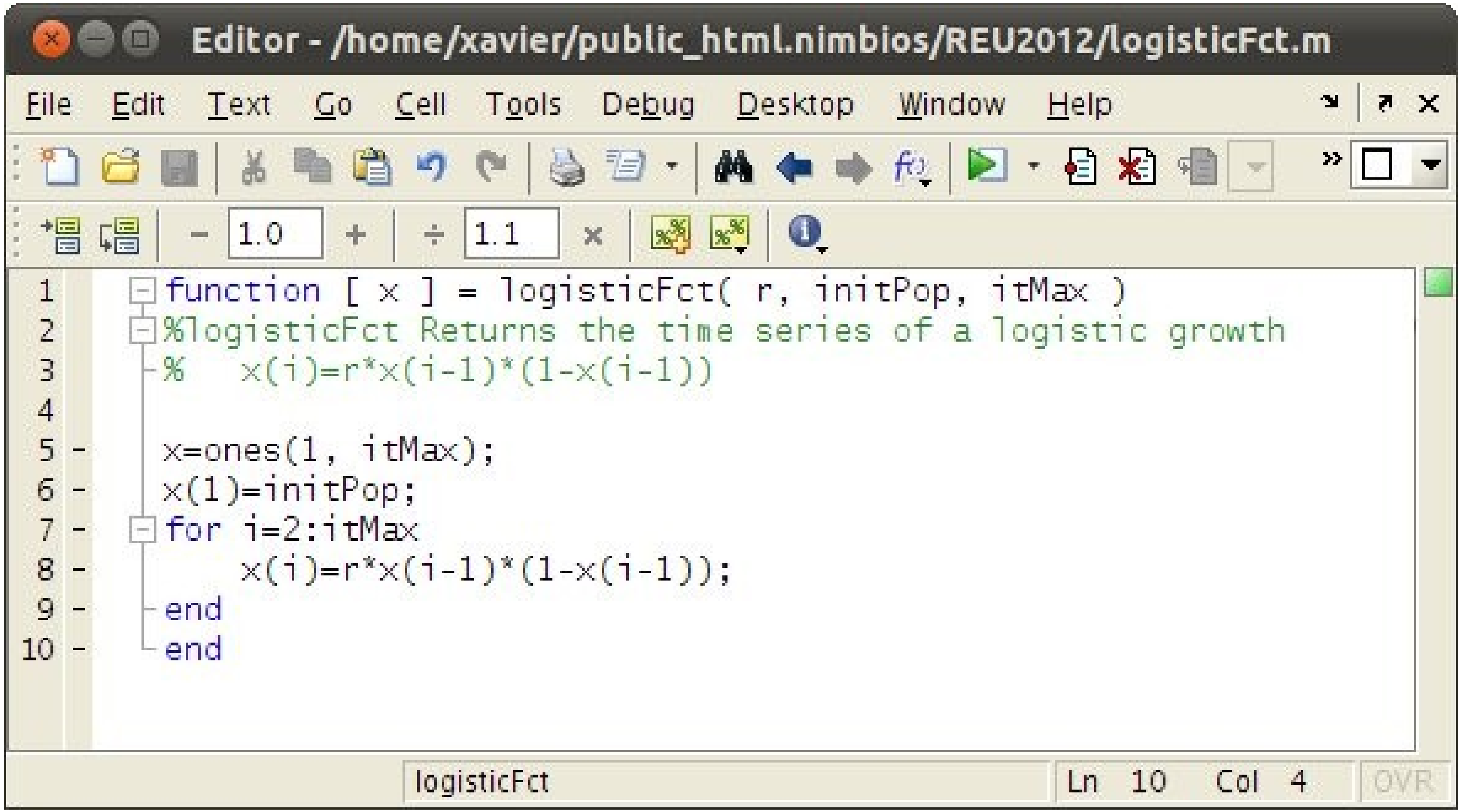
Logistic map

$$N_t = r\,N_{t-1}(1 - N_{t-1})$$

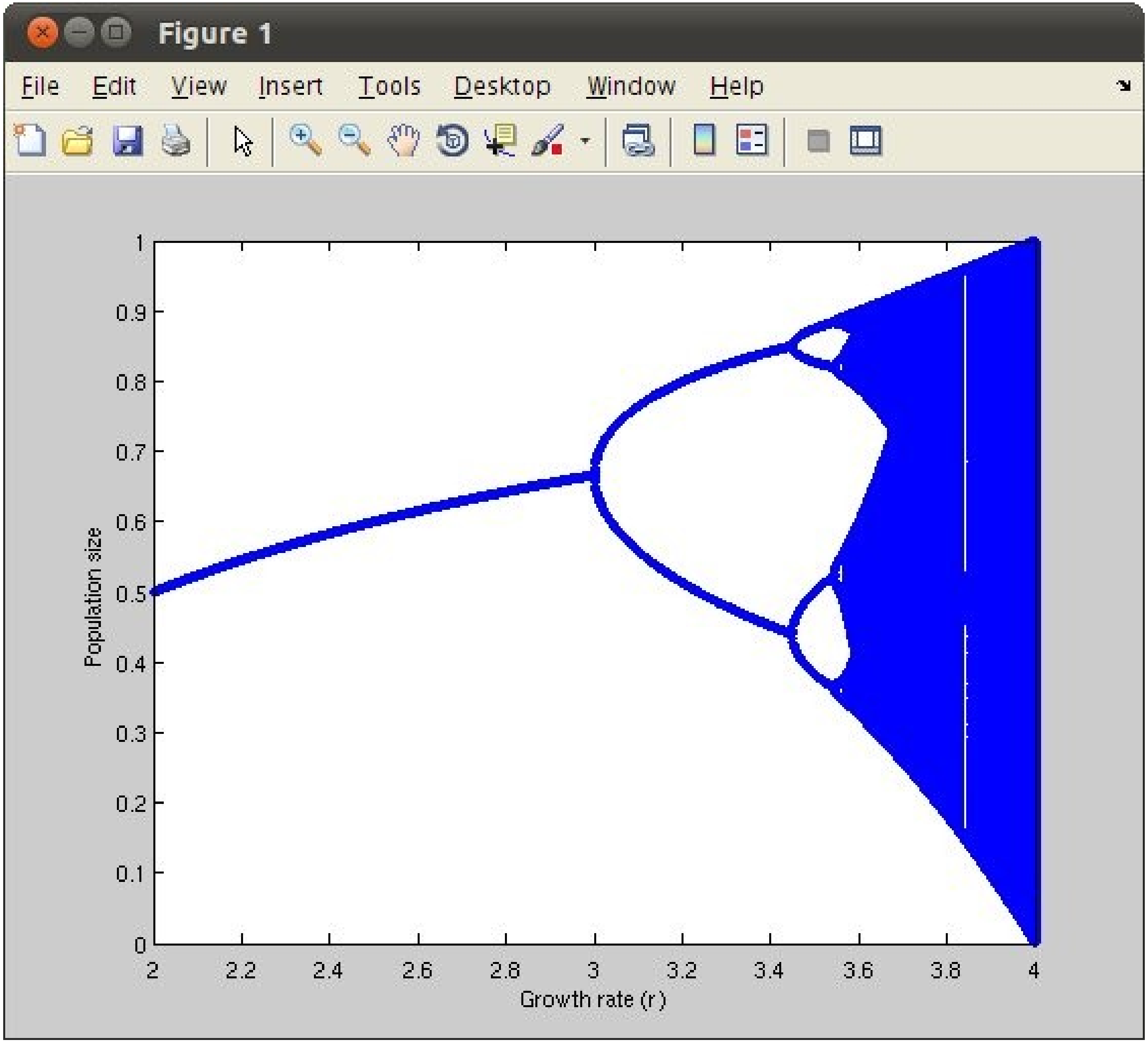


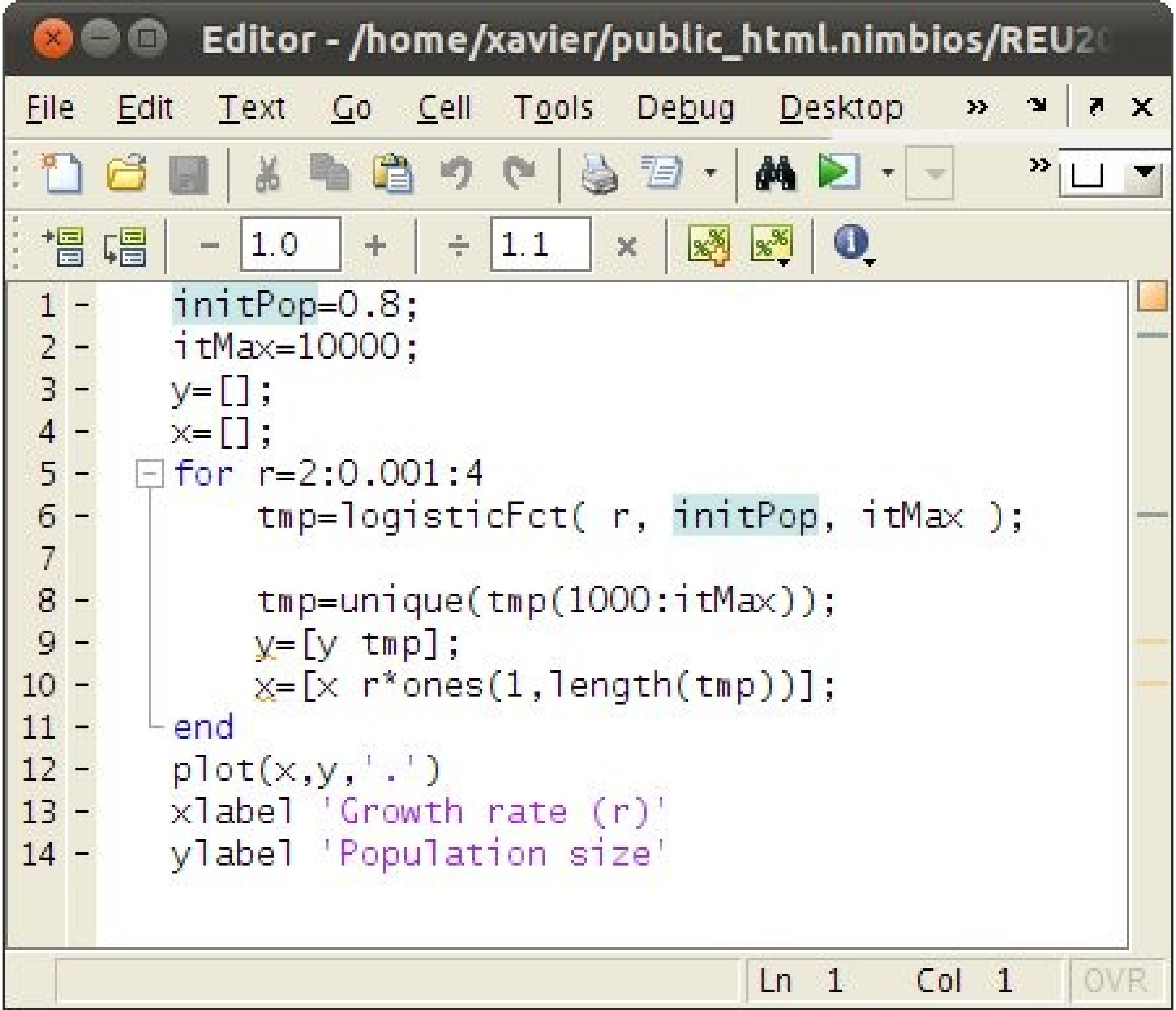
```
function [ x ] = logisticFct( r, initPop, itMax )
%logisticFct Returns the time series of a logistic growth
%   x(i)=r*x(i-1)*(1-x(i-1))

x=ones(1, itMax);
x(1)=initPop;
for i=2:itMax
    x(i)=r*x(i-1)*(1-x(i-1));
end
end
```

Exercise

- Study the behavior of the time series for
  - $0 < r < 1$
  - $1 < r < 2$
  - $2 < r < 3$
  - $3 < r < 3.45$
  - $3.45 < r < 3.54$
  - $r = 3.57$
  - $3.57 < r < 3.9$
- N.B. Start your population at around 0.8 and plot around 100 iterations

Bifurcation map



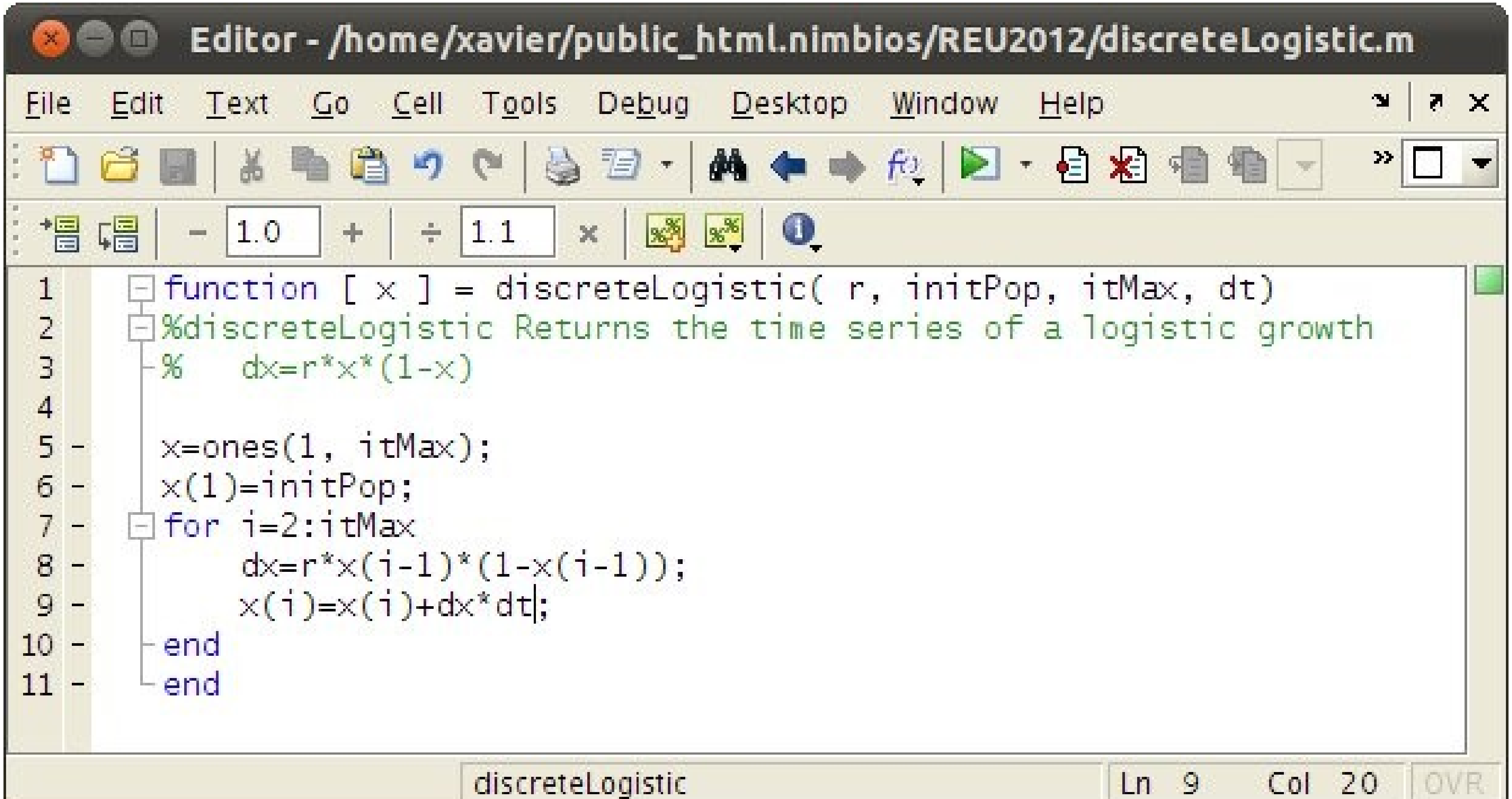


```
initPop=0.8;
itMax=10000;
y=[];
x=[];
for r=2:0.001:4
    tmp=logisticFct( r, initPop, itMax );

    tmp=unique(tmp(1000:itMax));
    y=[y tmp];
    x=[x r*ones(1,length(tmp))];
end
plot(x,y,'.')
xlabel 'Growth rate (r)'
ylabel 'Population size'
```

Difference equation

- Logistic

$$\Delta N = r\,N\left(1 - N\right)dt$$



```
function [ x ] = discreteLogistic( r, initPop, itMax, dt)
%discreteLogistic Returns the time series of a logistic growth
%   dx=r*x*(1-x)

x=ones(1, itMax);
x(1)=initPop;
for i=2:itMax
    dx=r*x(i-1)*(1-x(i-1));
    x(i)=x(i)+dx*dt;
end
end
```

Exercise

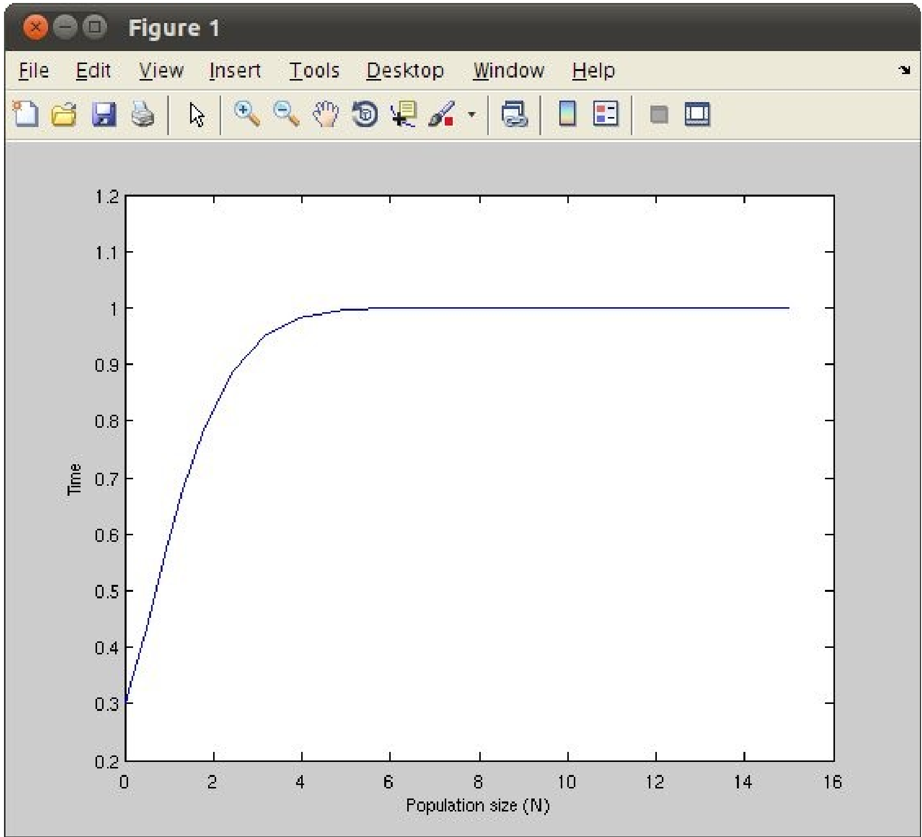
- Study the behavior at r=1.5 with different dt
  - Plot the time series, and label the x-axis correctly
  - Try different values, e.g. dt={0.001,0.01,0.1,1,2}.

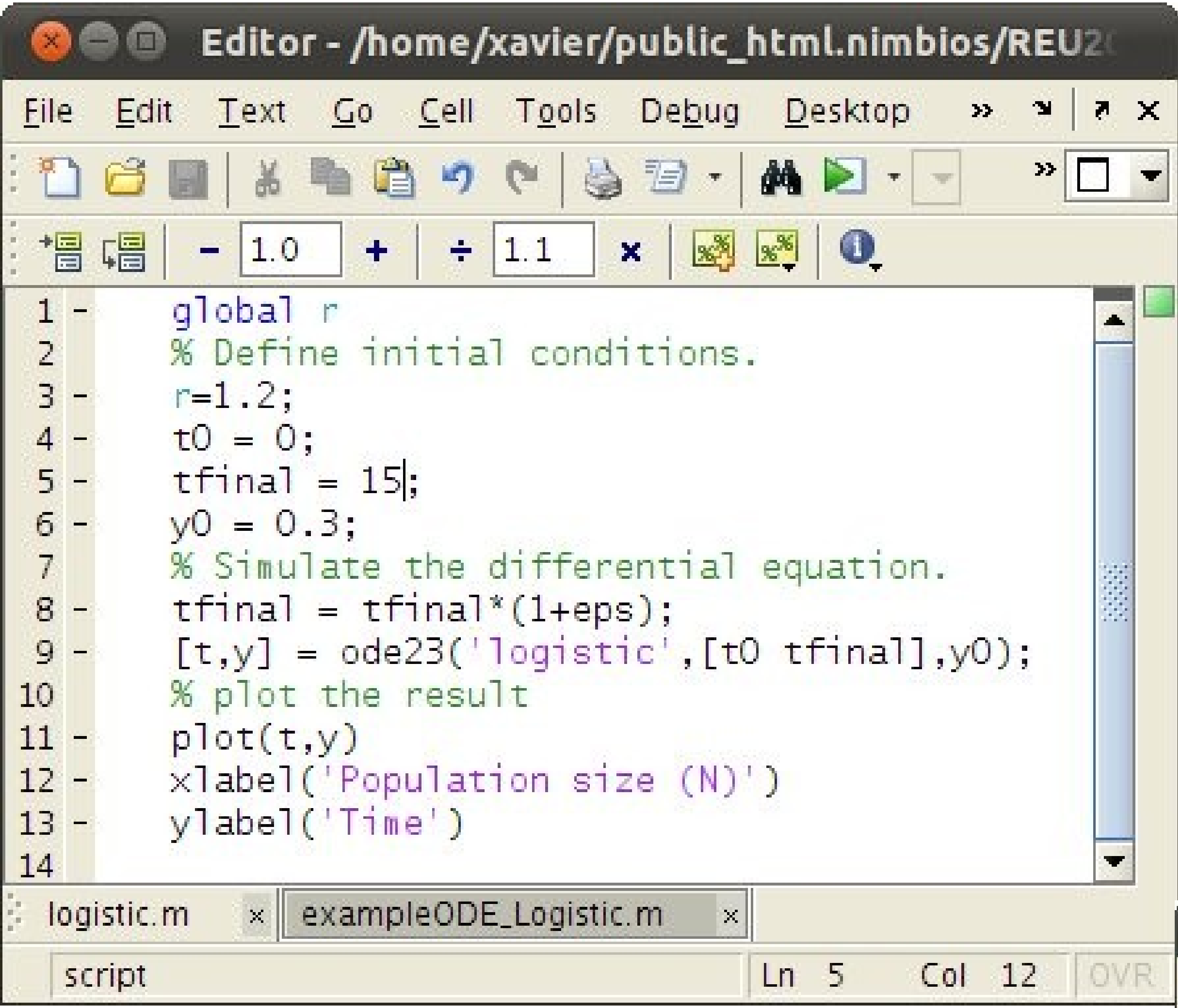
- N.B. Start your population at around 0.8 and plot around 100 iterations

Simple differential equation

- Continuous logistic growth

$$\frac{d\,N}{dt} = r\,N(1-N)$$

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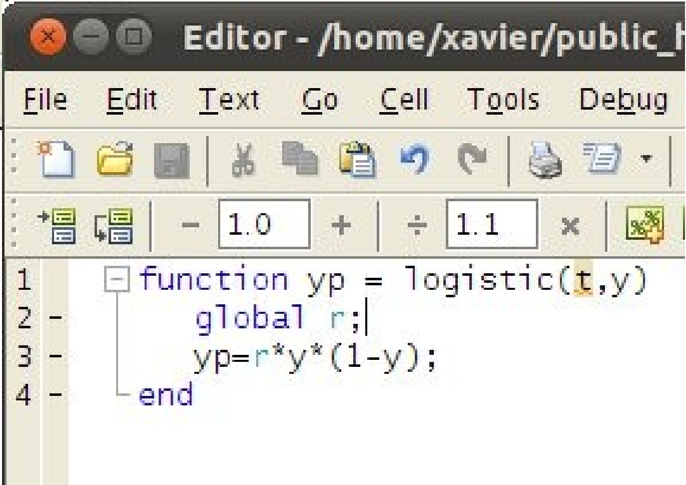
File Edit Text Go Cell Tools Debug Desktop
1.0
1.1
logistic.m
exampleODE_Logistic.m
script
Ln 5 Col 12
OVR

```
global r
% Define initial conditions.
r=1.2;
t0 = 0;
tfinal = 15;
y0 = 0.3;
% Simulate the differential equation.
tfinal = tfinal*(1+eps);
[t,y] = ode23('logistic',[t0 tfinal],y0);
% plot the result
plot(t,y)
xlabel('Population size (N)')
ylabel('Time')
```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1.0
1.1

```
function yp = logistic(t,y)
    global r;
    yp=r*y*(1-y);
end
```

Exercise

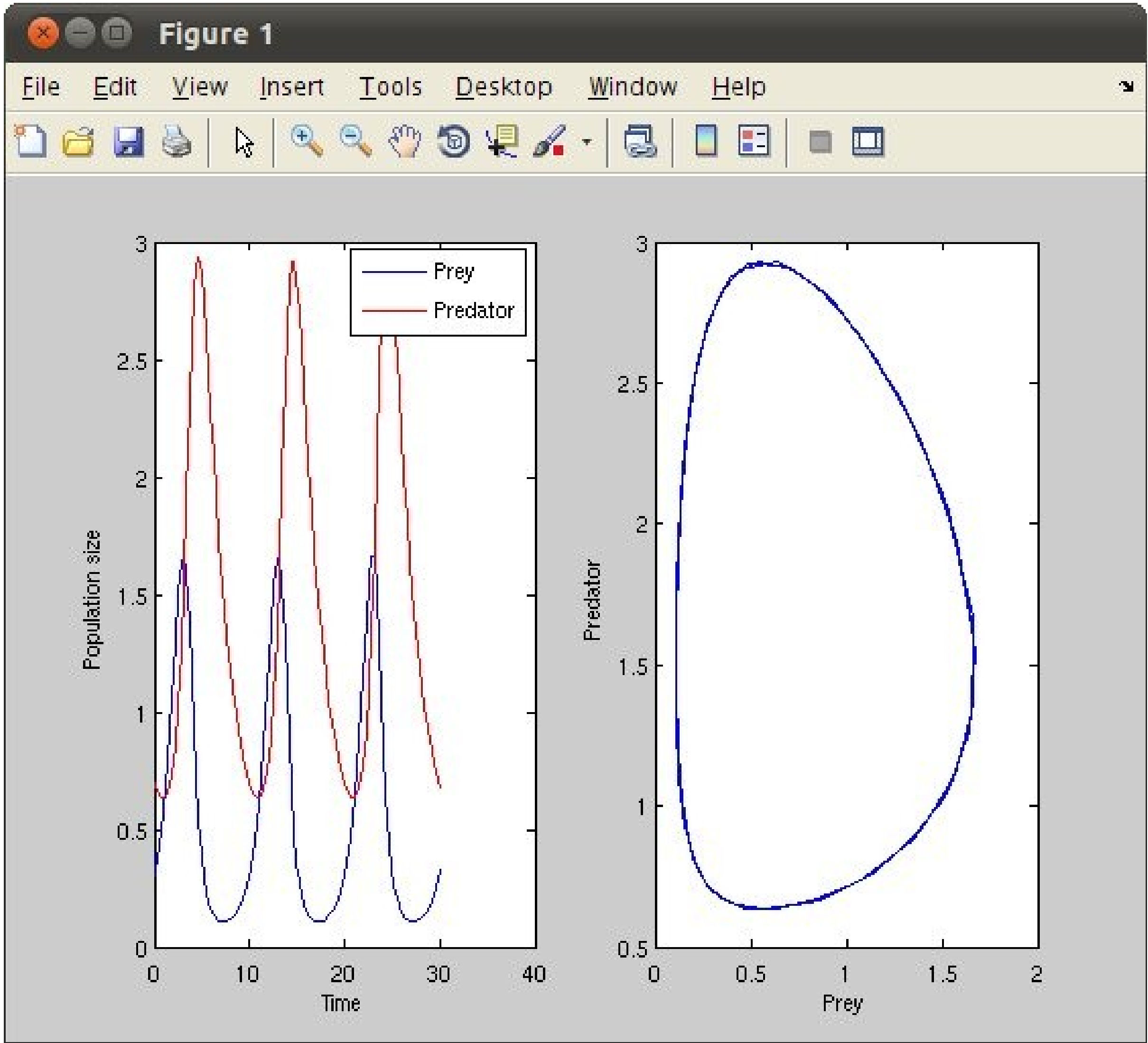
- Study the behavior of the time series for
  - $0 < r < 1$
  - $1 < r < 2$
  - $2 < r < 3$
  - $3 < r < 3.45$
  - $3.45 < r < 3.54$
  - $r = 3.57$
  - $3.57 < r < 3.9$
- N.B. Start your population at around 0.8 and plot around 100 iterations

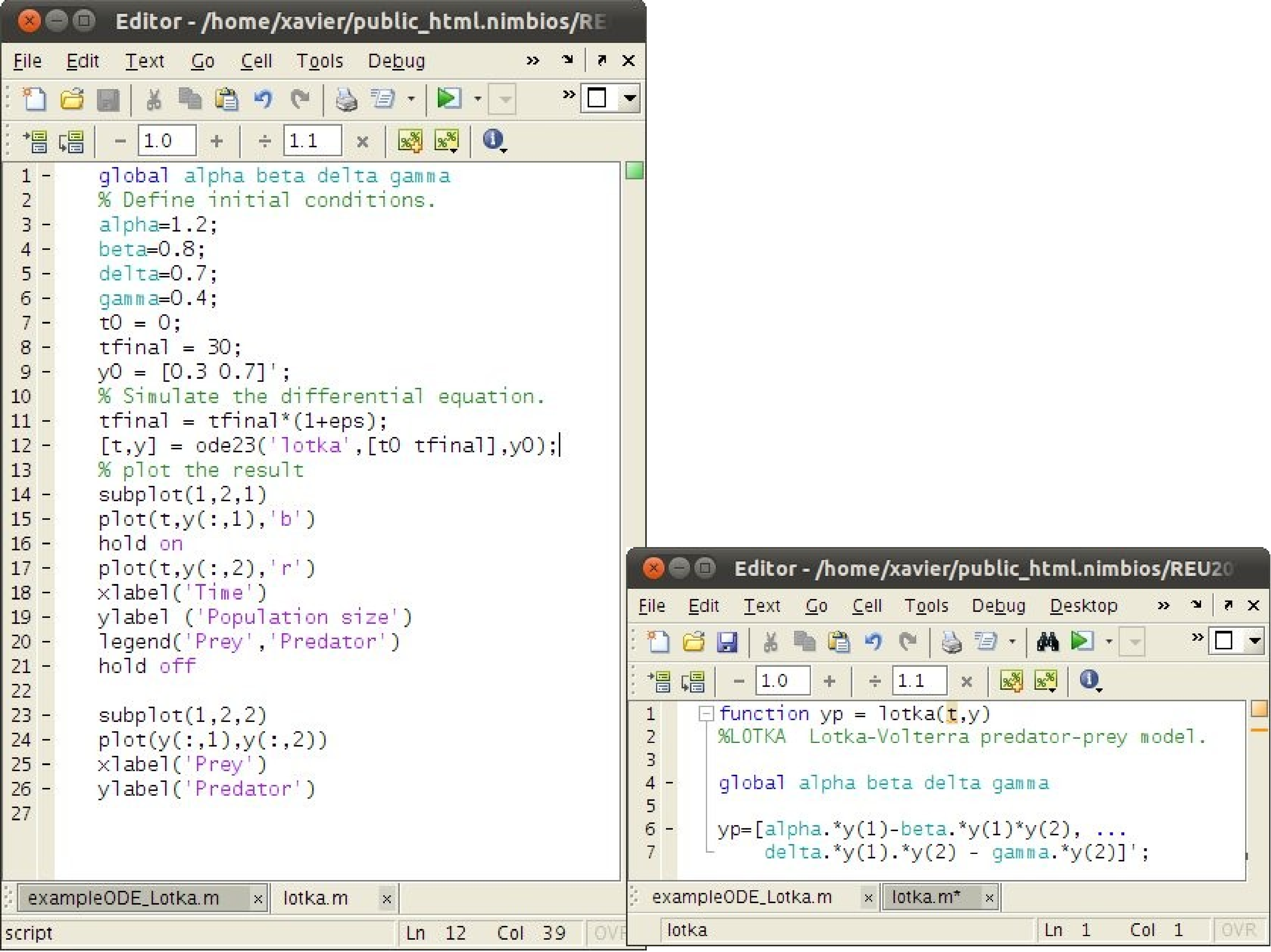
Some more differential equation

- Lotka-Volterra

$$\frac{dx}{dt} = \alpha x - \beta xy$$

$$\frac{dy}{dt} = \delta x y - \gamma y$$

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1.0
1.1
exampleODE_Lotka.m
lotka.m
script
Ln 12 Col 39
OVR

```
global alpha beta delta gamma
% Define initial conditions.
alpha=1.2;
beta=0.8;
delta=0.7;
gamma=0.4;
t0 = 0;
tfinal = 30;
y0 = [0.3 0.7]';
% Simulate the differential equation.
tfinal = tfinal*(1+eps);
[t,y] = ode23('lotka',[t0 tfinal],y0);
% plot the result
subplot(1,2,1)
plot(t,y(:,1),'b')
hold on
plot(t,y(:,2),'r')
xlabel('Time')
ylabel ('Population size')
legend('Prey','Predator')
hold off

subplot(1,2,2)
plot(y(:,1),y(:,2))
xlabel('Prey')
ylabel('Predator')

```

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1.0
1.1
exampleODE_Lotka.m
lotka.m*
lotka
Ln 1 Col 1
OVR

```
function yp = lotka(t,y)
%LOTKA  Lotka-Volterra predator-prey model.

global alpha beta delta gamma

yp=[alpha.*y(1)-beta.*y(1)*y(2), ...
    delta.*y(1).*y(2) - gamma.*y(2)]';
```

Exercise

- Modify the script to draw the isoclines

$$\frac{dx}{dt} = 0$$

$$\frac{dy}{dt} = 0$$

Thank you!