

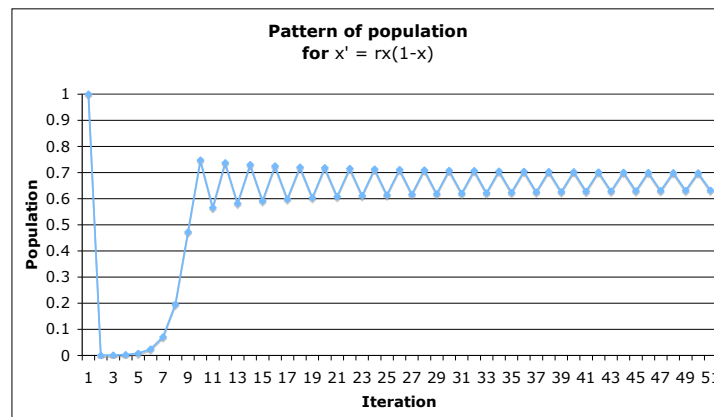


## Seminar 5: Leverage Points

- Systems Thinker Presentations (if any?)
- The bit on Chaos Theory that we didn't get to last time
- Limits to Growth (historical background)
- Exercise: Group Juggle
- Leverage Points in a System

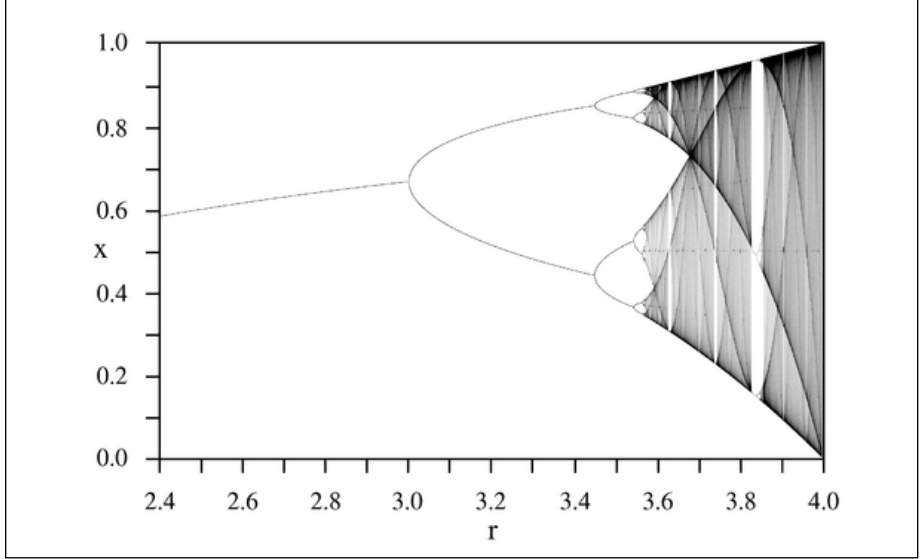


## Non-Linear Dynamical Systems





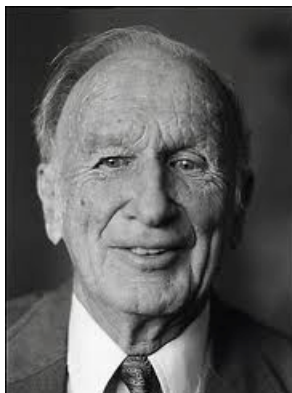
### Bifurcation Diagram for $x' = rx(1-x)$



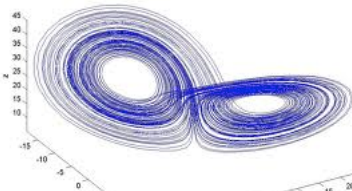
### The discovery of Chaos

**1950s: Edward Lorenz discovers non-linear effects in weather forecasting, develops Chaos Theory;**

**Basis for understanding what is predictable and what isn't**



$$\begin{aligned} \frac{dx}{dt} &= \sigma(y - x) \\ \frac{dy}{dt} &= x(\rho - z) - y \\ \frac{dz}{dt} &= xy - \beta z \end{aligned}$$





## Limits to Growth

### → Club of Rome formed 1968

↳ Founders: Aurelio Peccei and Alexander King

### → “Predicament of Mankind” -> Global Problematique

↳ Concept framed by: Hasan Özbekhan, Erich Jantsch and Alexander Christakis

### → “Limits to Growth” published 1972

↳ Based on Jay Forrester’s Systems Dynamics

↳ Study by Donella Meadows, Jorgen Randers and Dennis Meadows

↳ Updates:

↳ “Beyond the Limits to Growth”, 1992

↳ “Limits to Growth: the 30-year Update” 2004



## Key ideas

### → Finite planet has a “carrying capacity”

↳ {Population growth x ecological footprint} will eventually exceed it

↳ This happened sometime in the 1980s

↳ Reduction is inevitable; can be managed or can be collapse

### → The limits are on **flows**

↳ No limit on population per se; limits are on flows needed to sustain us

↳ E.g. extraction of raw materials, disposal of waste products

↳ Hence, population can overshoot carrying capacity

### → People tend not to accept a limit was reached until long after the collapse

↳ E.g. Dotcom “bubble”; banking crisis of 2007; ...





## Group Juggle

- **Aim: Keep as many balls in the air as possible**
- **Fixed throwing order – each person throws only to their designated catcher.**
- **I can throw to anyone not currently holding a ball**
- **As I see you successfully keeping more balls in the air, I'll throw in more and more balls.**



## Levels of Perspective

- **Events:**
  - ↳ *Who does what to whom?*
  - ↳ *What happened?*
- **Patterns:**
  - ↳ *Re-occurring patterns of behaviour*
  - ↳ *What is happening over time?*
- **Structure:**
  - ↳ *How are the parts of the system organized?*
  - ↳ *Why is this happening?*
- **Mental Models:**
  - ↳ *Assumptions or worldviews of participants*
  - ↳ *How do our mental models create or sustain the structure of the system?*

